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Case No: QB-2022-002405 and others

IN THE HIGH COURT OF JUSTICE
KING'S BENCH DIVISION

Royal Courts of Justice
Strand, London, WC2A 2LL

Double-click to add Judgment date

Before:

THE RT. HONOURABLE LADY JUSTICE COCKERILL

- -

Between:

VARIOUS CLAIMANTS	**Claimants**
- and –	
MERCEDES-BENZ GROUP AG AND OTHERS, FORD MOTOR COMPANY AND OTHERS NISSAN MOTOR CO., LTD AND OTHERS STELLANTIS AUTO SAS AND OTHERS, AND OTHERS	**Defendants**

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Representation: see Representation Appendix

Hearing dates:
6,9,13,14,15,16,20,21,22,23,29,30 October 2025
3,4,5,6,10,11,12,13,14,17,18,19,20,21,24,25,26,27 November 2025
1,2,3,4,8,9,10,11,15,16,17,18 December 2025
2,3,4,5,9,10,11,12,16,17,18,19,20 March 2026

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APPROVED JUDGMENT – SUBJECT TO EDITORIAL AND CLARIFICATORY CORRECTIONS

I direct that no official shorthand note shall be taken of this Judgment and that copies of this version as handed down may be treated as authentic.

This judgment was handed down remotely by the judge and circulated to the parties' representatives by email and release to The National Archives. The date and time for hand-down is deemed to be Friday 10 July 2026 at 1500

Lady Justice Cockerill:

PART 1

INTRODUCTION

1. It is a truth universally acknowledged that diesel vehicle engines produce a range of polluting emissions - and that these have come under increasing scrutiny since the 1990s. The product of that scrutiny was the cohort of regulations which lie at the heart of this case. Specifically, the EU introduced regulations which required diesel cars to pass an emissions test and (in very broad terms and subject to very narrow exceptions) also that they should not contain any devices known as "defeat devices".

2. A defeat device is defined (less than helpfully) as:

> "any element of design which senses temperature, vehicle speed, engine speed (RPM), transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use"[1]

3. Those regulations have been refined and tightened up considerably over the years. At different times the regulations have focused more or less on Carbon Monoxide ("CO"); unburnt hydrocarbons ("HC"); and Carbon Dioxide "(CO_2") a direct greenhouse gas, particulates and particulate matter ("PM") – and oxides of nitrogen ("NOx"), which is a collective term for gases including nitrogen monoxide and nitrogen dioxide. A variety of these are harmful to human health as well as to the environment. But for current purposes, the focus is on NOx.

4. NOx emissions are dangerous to human health and particularly dangerous in the urban areas where most driving takes place. NOx emissions also damage the environment in two ways. First, NOx can contribute to the formation of other pollutants, including particulate pollution and ground-level or "tropospheric" ozone, a particularly harmful gas both for human health and greenhouse gas effects. Second, high levels of NOx deposition can harm ecosystems, as NOx also contributes to the acidification and eutrophication of ecosystems, leading to biodiversity loss and damaging habitats.

5. Because of this, NOx emissions have now been regulated for some years; and the tests which take place today are very different to those which pertained at the time in focus in this case, which is around 2009-2016.

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[1] For the purposes of the arguments which ensue it can be broken down into the following elements:

"[1] any element of design [2] which senses temperature, vehicle speed, engine speed (RPM), transmission gear, manifold vacuum or any other parameter [3] for the purpose of activating, modulating, delaying or deactivating the operation of [4] any part of the emission control system, that [5] reduces the effectiveness of the emission control system under [6] conditions which may reasonably be expected to be encountered in normal vehicle operation and use."

6. In 2015 the relevant standard was known as "Euro 5"; and the new "Euro 6" standard was on the cusp of being introduced. 2015 is a key date in this case because in September of that year the US Environmental Protection Agency issued Volkswagen Group companies with a notice of violation under the US Federal Clean Air Act 1963. This was the start of what is popularly known as "Dieselgate". The way in which the relevant VW engine was found to work is considered in some detail below, but in effect it was calibrated so as to sense when the emissions test was being conducted, to work in an exemplary fashion in the test – and then switch to a different mode with a much less favourable emissions control results out of test. This was plainly what is referred to as a "prohibited defeat device" or "PDD" – that is a defeat device for which there is no excuse or applicable exception. Perhaps unsurprisingly the Claimants tend to prefer the even more emotive "cheat device".

7. In this litigation, the Claimants, some 1.6 million owners of diesel cars of Euro 5 and Euro 6 vintage (very roughly a 2012-2018 cohort), allege that their cars, manufactured by a wide range of well-known manufacturers[2], all contained devices which were also PDDs/"cheat devices".

8. An important point to note at the outset is that there is no allegation that any of them contained a device which is the same as the VW PDD at the centre of Dieselgate. Any thought that the answer to this case is obvious must therefore be put firmly to one side.

9. The devices alleged in this case are many (roughly 40, depending on how many are grouped together) and varied. They range from so-called "thermal windows" by which engines are said to have performed optimally in the test but markedly less well out of it, via modulations of the emissions control system when the vehicle is operating at high torque or speed, and into the finer detail of how Lean NOx Traps were timed to purge - or in cars fitted with catalytic converters, the way in which AdBlue was programmed to dose. Of the 40 defeat devices alleged, around 7 are said to be Test Cycle Recognition Defeat Devices ("CRDDs") and therefore akin to the VW "cheat device". The rest are simply said to be devices which mean that as a matter of fact, the way the car was calibrated means that the emissions control system works well in test and not so well out of test.

10. The arguments advanced by the parties have covered a wide disparity of views. The Claimants' case (in the barest summary) is that the emissions control systems of the vehicles should always perform outside the test required by the relevant regulation (including in temperatures as low as -15°C or as high as 40°C) more or less exactly like they do in the test; and that they may only fail to do so if either both safe operation of the vehicle and engine protection are imperilled or during engine start up.

11. To give an example: it is their case that a device that reduces the Exhaust Gas Recirculation ("EGR") rate by a fraction of a percentage point from the level at which it would operate during the test, for just a moment or two, and which operates only at -10ºC ambient temperature, is a PDD. The practical effect of their case would either be, or come close to being, that every single Euro 5 and Euro 6 vehicle produced by every single manufacturer contained a PDD.

[2] Mercedes, Ford, Renault/Nissan, Peugeot, Citroen, ,FCA/Suzuki,VW/Porsche,BMW, Volvo, JLR, Vauxhall, Mazda, Toyota, Hyundai Kia,(see list of representation at Appendix 1 for an exhaustive list)

12. In contrast some of the Defendants contend that the Regulations only outlaw true "cheat" devices, while others argue that emissions need to be viewed holistically, that it makes no sense to reduce NOx if the cost is increased CO_2, that increases in NOx can be counterbalanced by savings in other pollutants or factors (regulated and possibly also unregulated) and that there is a very wide margin for judgment by manufacturers as to both how to do that and to ensure vehicle safety. Thus at the other end of the spectrum of arguments some manufacturers' approach would come close to giving themselves *carte blanche* – so long as the test is passed.

13. As earlier "Pan-NOx" judgments have explained, in order to prevent this unprecedented series of overlapping cases overwhelming the courts to the prejudice of other litigants, all the diesel emissions cases have been ordered to be managed together, and via a series of case management conferences, orders have been made for trial of issues covering not just one manufacturer, but by reference to four lead Group Litigation Orders ("Lead GLOs"): Mercedes, Ford, Peugeot-Citroen and Nissan-Renault. These manufacturers were selected in part to offer a good range both of technologies and different approaches to calibration. The aim therefore is to produce results which are not just binding on those cases, but which offer real guidance in the remaining cases.

14. This trial does not cover every aspect of the disputes between the parties. All that this trial covers is a segment of the liability issues – specifically a number of agreed legal issues relating to the allegations of PDDs. However, even to determine these limited legal issues it has been necessary to examine the original and updated engine calibrations and computer software, to agree a cohort of sample vehicles, to "roll back" their software and calibrations and then to ascertain how the various sample vehicles performed in live testing (in the lab and on the road). All of this provides the basis to examine, in the context of those vehicles, whether the PDDs alleged in respect of those vehicles were established. It will be obvious that that consideration involves highly complex and technical expert evidence.

15. Because of the complexity of the case, this judgment is necessarily long and presented in parts – including appendices.

    i) Part 1 is the main part of the judgment, designed to be broadly accessible to the general reader (with occasional reference to the Appendices) as well as the parties. It will set out core background, the legal analysis and summary conclusions on the individual cases.

    ii) Part 2 of the judgment contains the detailed reasoning on the individual defeat devices alleged against each manufacturer.

    iii) Part 3 of the judgment contains the appendices which are likely to be necessary for any non-party at points:

        a) Appendix 1: Table of Representation

        b) Appendix 2: Table of Abbreviations. The case contains a bewildering number of abbreviations, but non-use of abbreviations makes the text even more indigestible than it already is.

c) Appendix 3: Technical Summary. This is based on a very helpful Contested Agreed Technical Document prepared by the parties. It is in essence the agreed portions of that document. Where contested parts of that document are relevant to issues for decision the answers to the contested parts will be found in the main body of the judgment.

16. A further mention needs to be made of complexity. Long as this judgment inevitably is, it can do no more than skate over the surface of the vast amount of evidence and submissions, with deeper dives where necessary to decide the issues. By way of summary explanation: written openings amounted to nearly 1,200 pages, closing submissions were nearly 2,000 pages. There were over 9,000 footnotes to the submissions. The experts' reports (without appendices) were over 10,000 pages.

17. In the section "The Trial/Open Justice" below is a description of the arrangements in place to ensure that the interested reader can access the full range of documents which entered the public domain via the trial process.

18. Before turning to the substance of the judgment, I would like to pay clear and explicit tribute to the teams involved in this litigation. The Managing Judges for the litigation (in sequenced combinations of two: Fraser J/Cockerill J/Constable J/Bright J) have explicitly set punishing schedules to ensure that the litigation moved as efficiently and as swiftly as possible through the courts. Huge factual, legal and expert detail has had to be mastered and deployed at speed.

19. While the early days of the litigation at first seemed to presage a fairly unreasonable and bunkered approach, with parties wasting time on recriminatory correspondence rather than progressing the litigation, the parties have responded admirably to judicial "encouragement" to co-operate and assist the court. Specific thanks are due to the core solicitor teams who have appeared regularly at the "management meetings" convened weekly or every two weeks to deal with issues arising in the day to day progress of this behemoth of litigation. The teams – counsel, solicitors, experts and witnesses – have worked extraordinarily hard over many weeks and months (including evenings, weekends and holidays). They have good-temperedly operated sardined into courts which have struggled to contain the hundreds of people sometimes requisite for parts of hearings and with the constant shifts of seating necessary to bring the right litigation teams close to the microphones.

20. And, as this judgment will demonstrate, they have never failed to find a telling phrase to adorn their arguments and to make their points vivid and memorable. Many of these gems will be found in the judgment below; those which did not make the cut were none the less appreciated. It has been an unusual pleasure and privilege to be involved in this case.

DEFINING TERMS: DIESEL ENGINEERING 101

21. The detailed description of how the relevant engines and ECS work is set out in Appendix 3. What follows is a very brief outline designed to enable the main part of this judgment to be read and understood as a self-standing document.

The combustion process and types of emissions

22. Diesel engines are powered by the combustion of diesel fuel. They operate by compressing inlet air (predominantly composed of oxygen and nitrogen) in the combustion chamber, causing it to reach such a high temperature that, when the diesel fuel is injected, the air-fuel mixture should auto-ignite in a spontaneous reaction. The combustion releases energy which drives the pistons of the engine, creating the mechanical force that powers the vehicle. The process can be broken down into four components:

    i) Intake Stroke: The piston moves down the cylinder and the intake valves open allowing intake gas mixture to enter the combustion chamber. The exhaust valves remain closed;

    ii) Compression Stroke: Both the intake and exhaust valves are closed. The piston moves back up the cylinder and the trapped mass of gas is compressed. This compression results in an increase in the temperature of the trapped mass of air;

    iii) Power Stroke: As the piston approaches the top of its stroke (referred to as top dead centre or "TDC"), diesel fuel is sprayed at high pressure into the combustion chamber by the fuel injector and combusts with the compressed and hot air in the combustion chamber. The increase in the gas temperature which results generates pressure which forces the piston down and generates mechanical force which is transmitted to the powertrain via the crankshaft;

    iv) Exhaust Stroke: The exhaust valve opens, and the returning piston forces the burnt gases out of the combustion chamber through the exhaust valve. The intake valve remains closed.

23. The process creates combustion products which include: CO_2, Water ("H_2O"): CO, HC from unburned fuel and entrained lubrication oil constituents, NOx including both nitric oxide ("NO") and Nitrogen Dioxide ("NO_2"), PM, and other combustion products are generated such as Sulphur Dioxide ("SO_2") from the small amounts of sulphur present in diesel fuel and in engine lubricating oil.

24. NOx in particular is created in the combustion chamber by the reaction of nitrogen with oxygen at high pressure and high temperature. Generally, higher levels of NOx are produced when there is greater oxygen concentration and high pressure and higher temperature.

25. Diesel engine emissions are affected by the local conditions including air to fuel ratio ("AFR"), temperature and pressure at the points of combustion across the combustion chamber. For example, higher local temperatures and oxygen availability tend to result in more complete combustion and consequently reduced emissions of CO, HC, and PM. However, the trade-off is that the higher combustion temperatures and oxygen concentration can lead to an increase in NOx, which is formed more readily at elevated temperatures.

Systems to control NOx: ECS and calibration

26. There are two primary routes to control NOx: technology and its selection, and the calibration of those technologies and other systems. Nearly all of the devices at issue in this trial concern one of the following three technologies:

    i) EGR, either high pressure EGR ("HP EGR") or low pressure EGR ("LP EGR");

    ii) Lean NOx Trap ("LNT"); or

    iii) Selective Catalytic Reduction ("SCR"). The primary purpose of each of these technologies was to control NOx emissions.

27. Calibration is a key part of the design of these vehicles. It involves controlling each calibratable variable in the software. It is by this process that the parameters of the alleged PDDs were defined, by choices such as the particular temperature at which the ECS in question would be de-rated or switched off, with the attendant increase in NOx emissions.

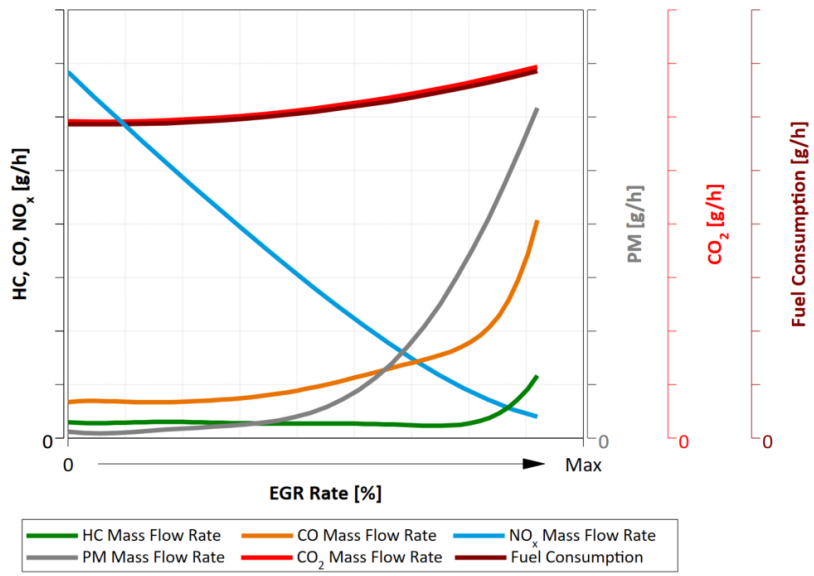
28. The following ECS systems were included in the Core Sample Vehicles ("CSVs"), with Euro 5 vehicles in blue and Euro 6 vehicles in red:

Lead D	HP EGR	LP EGR	LNT	SCR
Mercedes	MBC1 MBC6, MBD1, MBD6			MBC6, MBD1, MBD6
Ford	FC1, FC5, FD3 FC6, FD5, FD1		FC6, FD5	FD1 (plus, with passive SCR only: FD5 & FC6)
PCD	PCDC6, PCDD4 PCDC3, PCDD1			PCDC3, PCDD1
Renault	RC3 RC2, RD2	RC3 RC2, RD2	RC2, RD2	
Nissan	NC1 NC2, ND1	NC1 NC2, ND1	NC2, ND1	

("EGR")

29. ("EGR") involves recirculating engine exhaust gas (which after combustion is now low in oxygen) back into the engine's air intake tract using a valve (the "EGR Valve") in the engine's exhaust tract. Recirculating exhaust gases into the combustion chamber generally results in lower oxygen concentrations and an increase in the specific heat of the combustion gases, leading to lower combustion temperatures and thus lower NOx. The use of EGR resulting in sub-optimal fuel ignition and combustion conditions generally leads to lower engine efficiency (i.e. fuel economy), and higher CO^2, CO, HC, and PM emissions. This can be illustrated thus:

Typical Diesel Engine Emissions Response to Changes in EGR Rate



30. The functioning of the EGR system is primarily regulated by changing the position of the EGR valve(s). The functioning of the EGR system is controlled by the car's Engine Control Unit ("ECU"), a computer which adjusts the EGR Valve during driving so as to allow more or less recirculation (the "EGR rate") depending on the demands placed on the engine from moment to moment. As far as the valve is open, exhaust gases can pass through it enabling the recirculation of the exhaust gases into the engine's air intake. The degree of opening of an EGR valve can be adjusted to allow more or less exhaust gases to be recirculated.

31. The HP EGR directs Combustion Products from the exhaust manifold, at a position upstream of the turbine, to the intake manifold; the exhaust gases are taken from just after the combustion chamber, before the turbocharger turbine. They are then recirculated without any filtration back into the combustion chamber, after the compressor.

32. A LP EGR can be added into an EGR system to create a Dual Loop EGR. Of the CSVs, all the Renault and Nissan CSVs had a Dual Loop EGR, and did so from Euro 5; but the rest of the CSVs used only HP EGR in both Euro 5 and Euro 6. A LP EGR generally involves an EGR circuit being placed after the turbocharger turbine and sometimes also after at least some of the after-treatment systems (usually downstream of the DPF). It directs the exhaust gas from the turbocharger turbine to the turbocharger's intake, where the pressure is lower. The LP EGR systems in the Nissan and Renault CSVs took exhaust gas from much further downstream, past the turbine, DOC and DPF.

33. The LP EGR uses cleaned exhaust gases (because the intake is downstream of the DPF/DOC, and thus purged of PM, HC, and CO) and so has lower sooting and related risks. It uses cooler exhaust gases (because they are taken from a cooler point in the exhaust system, and then further cooled) which can have a greater effect on reducing NOx production by further reducing combustion temperature. Further, when LP EGR is used, all exhaust gas passes through the turbine, and none is diverted. This increases the effectiveness and power of the turbocharger, and the engine's power. In general terms LP EGR is better suited to high loads and engine speeds, and after engine warm-up, while HP EGR is more suitable while the engine warms up.

34. All of the CSVs have some form of EGR cooler. An EGR cooler reduces the temperature of exhaust gases, increasing their density, thereby increasing the effect of recirculation (a more dense mix of deoxygenated cooler air brings greater reduction in oxygen concentration and in combustion temperature), reducing NOx production. A cooler bypass avoids the cooler where cooling is not helpful (e.g. during warm up) or to mitigate the risks of deposit build up or condensation. Each CSV with just an HP EGR had a HP EGR cooler with a bypass. The Renault and Nissan systems had no cooler on the HP EGR, but a cooler on the LP EGR without a bypass.

35. The EGR rate is the percentage of the total charge air flowing into the combustion cylinders that comprises recirculated exhaust gas (the rest comprising fresh intake air).

36. In some of the CSVs (Mercedes, and some Ford), the EGR rate is set directly by the EGR rate set point, but in most of them (within vehicles of all Lead Defendants other than Mercedes) it is set by reference to the MAFSP, a set point programmed in the firmware, essentially a target or desired MAF. This is how the VW EA189 engines under consideration in *Crossley & Ors v VW AG* [2020] EWHC 783 ("*Crossley 1*") operated.

37. The MAF, which is constantly measured by a MAF sensor, is the mass of air entering the combustion chamber per stroke. Where there is a disparity between the MAFSP and the MAF, the system adjusts the position of the EGR valve.

38. It is agreed that a lower MAFSP results in the EGR rate being increased; a higher MAFSP results in the EGR rate being decreased. There is, at least in some cases, a question as to the linear and causative nature of that link.

39. There is also a hotly fought issue as to how EGR rate impacts NOx production – directly, indirectly or otherwise.

40. It is agreed between the experts that recirculating exhaust gas into the combustion chambers "generally" lowers NOx, which correlates to some extent with the agreement that the EGR is designed to *"decrease the formation of NOx"* and to *"support the control of NOx emissions"*. In *Crossley 1* it was likewise agreed that: *"in general terms, a higher EGR rate will lead to a reduction in the amount of NOx ultimately leaving the chamber"*.

EGR related risks

41. There was no agreement by the Claimants to the CATD text relating to risks; however while there is a vibrant debate about the severity of identified risks, and the extent to which they might be apt to engage Article 5(2) exceptions, the fact that such risks are identified and thought about was not really open to debate.

42. The passage which follows, drawn from the Defendant text in the CATD, is intended simply to give an overview of some of the risks identified and to make findings that they are risks which are known about. The contentious issues as to severity/application are for later.

43. Sooting and lacquering (varnishing) are forms of deposit which can develop in parts of the EGR system. Sooting is primarily a dry deposit, caused by the deposition and impaction of soot particles and ash, caused by, *inter alia*, thermophoresis, and which may occur as soot particles only or in combination with the condensation of HC and/or acids

forming a sticky base layer within parts of the EGR system. The heavy boiling hydrocarbons and sulphuric acid are particularly resilient.

44. Lacquering is generally an adhesive varnish, primarily caused by the condensation and/or thermophoresis of HC and other volatiles, also with the support of additive and oil residues (for example from a crankcase ventilation systems). Lacquering differs from sooting in its physical and chemical properties, including as to stickiness and plasticity, and different lacquers will themselves have different properties.

45. These types of deposit can occur throughout the EGR system, including the EGR valve, the EGR inlet (mixer), the EGR cooler, and anywhere in the EGR path. In addition, deposits may form in the inlet manifold, swirl flaps or inlet valve.

46. In some cases they may result in partial or complete blockage of components and/or sensor malfunction. For example, sooting and/or lacquering of the EGR valve may also decrease the EGR valve's responsiveness to instructions provided by the ECU, and may cause it to "stick" in a position – which in turn can lead to increased PM formation, or overheating. In HP and LP EGR systems sooting can lead to slightly different problems, particularly to the turbocharger. If the EGR valve becomes stuck open it can in due course lead to problems such as hesitation, jerking, uneven engine idling, and engine stalling. Sooting can also lead to EGR cooler overheating or failure, serious issues in the DPF, and fuel in oil dilution.

47. Sooting and lacquering can also (via a variety of individual issues) lead to unstable combustion and misfire which can themselves lead to jerkiness or unexpected loss of power.

48. In LP EGR systems there is also a risk of ice formation from condensation when the engine operates at low temperatures, as well as damage to parts either from water instead of gas entering the combustion chamber or from erosion.

Exhaust Aftertreatment System

49. A diesel engine's Exhaust Aftertreatment System ("EATS") comprises the emissions control components in the exhaust line after the turbocharger but before the silencer/muffler. The EATS can have a significant effect on the tailpipe emissions by reducing the pollutant levels from the exhaust gas at the outlet of the combustion chamber. The effectiveness of the EATS is dependent on a number of factors, including but not limited to the concentrations of pollutants in the exhaust gases at the outlet of the combustion chamber, the flow-rate of exhaust gas through the EATS components and the temperature of the exhaust gas and the EATS components. EATS components may be combined together or be configured individually. Those which are of relevance for present purposes are:

    i) SCR: a type of catalytic converter which converts (or reduces) NOx into H_2O and N_2;

    ii) LNT: a different catalytic device which converts (or reduces) NOx into H_2O and N_2;

iii) Diesel Oxidation Catalyst ("DOC"): a device that converts, through oxidation CO, HC and some PM into water vapour and CO_2; and

iv) Diesel Particulate Filter ("DPF"): a device designed to remove PM from the exhaust gas of a diesel engine.

SCR

50. An SCR system is a type of catalytic converter which reduces NOx into water (H_2O) and N_2 using a chemical reaction of NOx with a reducing agent. The SCR converts NOx through the injection of Diesel Exhaust Fluid ("DEF" (also commercially known as ("AdBlue") into the hot exhaust gas, where it converts to ammonia and passes over a rare metal catalyst, thereby inducing the reduction of NOx to nitrogen, CO_2 and water.

51. The reducing agent can be obtained by injecting or dosing into the exhaust stream an ammonia precursor such as AdBlue consisting of a urea-water/ammonia solution (NH_3). The SCR Catalyst is where the chemical reactions occur in the SCR process. It contains the reduction catalyst which is necessary for this reaction to occur and typically uses a coated substrate. The precise SCR Catalyst used will vary between vehicles.

52. The SCR treats NOx responsively: it must have NH_3, available to convert NOx as and when it arises. For this catalytic reaction to occur, the SCR catalytic converter must typically be at a temperature of above 180°C (depending on the construction of the SCR catalytic converter), with optimum conversion happening around 350°C. When sufficiently heated and with a filled catalyst, SCRs can achieve NOx conversion rates in excess of 90% (i.e. converting 90% of the engine-out NOx to nitrogen and water vapour). If dosing stoichiometrically[3] to maintain a filled catalyst at normal operating temperature, the more NOx that is there to be treated, the more AdBlue will be consumed to treat it, and *vice versa,* subject to the limits of the system.

53. The SCR systems in the CSVs source NH_3 in different ways. FD5 and FC6 have **passive** SCR systems, where no AdBlue dosing occurs. The purging of the LNT produces very small amounts of NH_3 which are used by the passive SCR to convert NOx.

54. The remainder have **active** SCR systems, which rely on the injection of AdBlue into the exhaust gas, which breaks down in the Conversion Reaction. For active SCR systems AdBlue dosing can only effectively occur above a certain minimum temperature at which it decomposes into NH_3 in the Conversion Reaction. Below that temperature, there is a risk of white deposits caused by solidification of unreacted or partially decomposed AdBlue.

55. An AdBlue tank can only produce a finite amount of NH_3 before it needs to be refilled. As such, the tank can supply NH_3 to convert a maximum amount of engine-out NOx before it requires refilling. When the CSVs were released, one issue was a desire to ensure that customers did not have to refill their AdBlue tanks themselves (i.e. that refilling could align with planned service intervals). Professor Martinez Botas gave clear evidence as to this being a concern, and further evidence of it can be seen in the European Commission decision on the cartel found between Mercedes and others in 2015 which

[3] Injecting enough AdBlue to replace all NH_3 from the catalyst that has been used to reduce NOx.

considered the issues as to the need to develop a delivery infrastructure if customers were to be expected to refill tanks themselves.

56. Three possibilities could ensure this:

    i) Increasing tank sizes.

    ii) Controlling demand (NOx creation). The OEM could reduce engine-out NOx, for example by using increased EGR.

    iii) Controlling supply (NH_3 dosing). The OEM could reduce how much AdBlue was dosed per km, irrespective of the engine-out NOx, to ensure it did not run out between service intervals.

57. Whether each relevant manufacturer took the course that it did in relation to SCR systems to control consumption or for other reasons is a question very much in issue in the SCR DDs.

Factors affecting the efficiency of the SCR

58. The efficiency of the SCR is dynamic, depending upon a number of factors including (i) available NH_3 and (ii) its operating conditions.

59. First, the efficiency of the SCR system is critically dependent upon how much NH_3 is stored on the catalyst. Dosing strategies that maintain the maximum safe NH_3 load for the SCR temperature do so to generate the maximum NOx conversion efficiency for those operating conditions; that is "*the fundamental purpose of the fill level*". A dosing strategy that depletes the catalyst (i.e. throttles dosing) will reduce the SCR's efficiency. The SCR is a storage device, so as you use the storage up, it has less and less conversion capability. As a general proposition an SCR operates at a lower conversion efficiency if it has less stored ammonia.

60. Secondly, the temperature of the SCR plays a crucial role. Once dosing and reduction has started, the temperature of the SCR affects: (i) the mass of NH_3 that can be stored on the catalyst to be available for reaction; and (ii) the speed of the Reduction Reaction, which affects what proportion of NOx can be converted with the NH_3 available. In general terms, the catalyst first has to heat to an operating temperature. But then if SCR temperature continues to increase, the catalyst can store less NH_3, but the NH_3 available (either as stored or being converted) can react more quickly with NOx. A wide variety of factors can affect the temperature of the catalyst including ambient temperature, the temperature of the exhaust gas, the placement of the SCR relative to the combustion chamber, engine load and speed, and EGR rate.

61. Thirdly, the size of the catalyst determines how much capacity it has to store NH_3, as well as determining the residence time of exhaust gases (i.e. the time such are exposed to stored or converting NH_3). Subject to temperature, a larger catalyst will be able to store more NH_3 (on the catalyst's surface) than a smaller one; and will invariably have longer residence times, though it will take longer to warm up. The ability to store more NH_3 results in the potential: (i) to make more NH_3 available for conversion with NOx; and / or (ii) for buffer capacity to mitigate against the risk of what is known as "Ammonia slip".

SCR related risks

62. Ammonia Slip is the most often mentioned SCR-related risk. It occurs where unreacted ammonia may pass through the SCR catalyst and be emitted via the tailpipe. Decreased efficiency in the ammonia-NOx reaction may therefore increase the amount of ammonia that remains unreacted, and may therefore lead to increased Ammonia Slip. Ammonia Slip has to be minimised as ammonia is a toxic pollutant which is hazardous to human health and the environment.

63. The SCR system also carries risks in the form of damage from urea crystals if there has been AdBlue overdosing. While these largely affect SCR efficiency in some cases there might be a blockage leading to partial or even complete loss of power.

LNT

64. NOx Storage Catalyst or LNT is part of the ECS of a vehicle. It is a type of device which reduces NOx by first storing it as stable nitrates and then purging into H^2O and nitrogen (N_2). Generally, an LNT Catalyst consists of precious metals, a storage medium, and a high surface area support material typically comprised of a honeycomb ceramic substrate which provides a large surface area for the precious metals and storage elements to disperse on (maximising the contact between the exhaust gases and the catalytic components). An LNT therefore acts like a molecular sponge, chemically trapping NOx emissions by adsorption rather than converting them.

65. Once the trap is full, it is unable to adsorb further NOx. It must therefore periodically be regenerated (in a similar way to the DPF) by briefly creating "rich" conditions (involving the use of additional fuel and/or changed fuel injection timing) in the exhaust. When this happens, the trap releases the NOx and converts it to nitrogen and water vapour. The frequency with which such regenerations are required will depend on the size and design of the system and upon driving conditions, but it is typically several times an hour.

66. The LNT system operates in a two-stage cycle by:

    i) Collecting NOx emissions within a catalyst (the "LNT Catalyst") when the engine is running on a lean mixture (the "Loading" or "Lean" Phase);

    ii) Purging the stored NOx by a process which converts the stored NOx into other compounds, including water.

67. This sounds ideal. However LNT systems have peculiarities and limitations: LNT DeNOx events are limited by physico-chemical requirements. So in the first place, the Loading Phase operates by oxidation of NO to NO_2, catalysed by precious metals on the surface of the support material, and by adsorption of NO_2 onto the storage element. The operation and effectiveness of the NOx adsorption depends on the exhaust temperature and exhaust flow. It follows that there is a range of operating temperatures within which the LNT Catalyst is effective for NOx adsorption. It will not work below about 150°C, but above a certain temperature, an LNT Catalyst can no longer store NOx and further NOx is released untreated resulting in "NOx Slip".

68. Secondly an LNT Catalyst also has limited capacity as it has a finite surface area and adsorption sites for NOx. As more NOx is adsorbed by the catalyst, it becomes saturated

and its ability to continue adsorbing NOx is reduced and eventually stops entirely. Both the temperature range and the maximum amount of NOx that can be stored reduce as the LNT ages.

69. The duration of the Loading Phase varies and is of the order of 30 seconds to a few minutes.

70. The purging of the LNT occurs via an "*active regeneration process*" over a few seconds whereby NOx stored in the LNT Catalyst is converted to N_2, CO_2 and H_2O (carbon dioxide and water). This is done via a periodic "rich spike" mode which makes the engine run a rich mixture (i.e. to use extra fuel). That spike produces HC and CO as chemical by-products from the combustion chamber which then react with the stored NOx to purge the LNT. The Rich Phase not only increases fuel use but also affects efficiency of combustion and leads to oil dilution, which may necessitate more frequent oil changes.

71. The LNT therefore requires control of the engine combustion parameters to switch from the normal, lean operation of the diesel engine to this "rich spike" mode. Purging requires not just rich conditions but also holding the LNT temperature within a certain range for several seconds. The Purging Phase is only possible when the LNT Catalyst and engine have reached a sufficiently high operating temperature. In the optimum temperature range from 300°C to 450°C there is a greater chance of significant quantities of NOx being released from the LNT.

72. In addition, the Purging Phase is only possible when the driver demand is relatively stable; if it is not the purge may be interrupted and incomplete. If a purge is incomplete it will fail effectively to reduce the NOx, again releasing untreated NOx instead of reducing it to harmless nitrogen. Indeed "bad purges" – incomplete purges in rich spike conditions can result in more NOx being released than if there is no LNT at all, with some of the NOx stored on the LNT catalyst being released as NOx (recorded as "*desorption phases following purge events*" in Ford testing records).

73. So the ECU will be programmed to initiate an LNT regeneration when one of a set of predefined "DeNOx Rules" is fulfilled. For each Rule, there are certain activation conditions or "Bits" which determine whether that Rule is activated. Exactly what those Rules are and how they are calibrated involves engineering judgement.

74. The LNT is a "continuously regenerating" system as far as the relevant regulations are concerned, meaning that LNT purging occurs frequently enough such that it is always included in the certification test cycles.

75. The LNT efficiency also reduces due to build up of sulphur oxides ("SOx") on the catalyst surface thereby reducing the available sites for adsorption of NOx. The SOx results from the oxidisation of the sulphur that is found in the fuel and lubricating oil. To maintain efficiency, the LNT must undergo a periodic removal of SOx ("DeSOx") phase which involves running in a rich mode at very high exhaust temperature. If DeSOx does not occur, or is not carried out properly, the LNT will become partially or wholly ineffective, and NOx will flow through the LNT without being adsorbed. The Claimants say that effectiveness of the LNT in the Ford LNT CSVs (FD5 & FC6) was significantly reduced by reason of SOx poisoning; but this is not a pleaded allegation for determination at this hearing.

76. LNT therefore has complications and disadvantages. History has shown that it has not become the preferred technology, with SCR becoming dominant. However at the time that the vehicles in question were developed, SCR was to some extent (and the question of extent is a controversial point) an emerging technology. LNTs were used by some of the manufacturers because they were cheaper to install than SCR and they did not raise the AdBlue dosing puzzles which are seen in considering the SCR allegations. In closing the Claimants have come close to saying that LNT was a technology which should not have been used. That is not an argument which was pleaded, nor is it an argument which is supported by the evidence. LNT was a perfectly permissible technology to use, but there remains a question as to whether it was used in a way which was permissible.

LNT risks

77. Other than efficiency issues such as inadequate purges (leading to increased tailpipe emissions) the main issues of LNT systems are excessively high temperatures resulting from poor purging leading to thermal stress, overheating and physical damage to e.g. EGR components and the intake manifold and related sensors (which may in turn lead to loss of power and inability to control airflow).

Systems to control other emissions

DPF

78. The control of particulates is a matter which has come to the fore in the years since these vehicles were manufactured. Control of particulates for example is a key part of London's ULEZ and other low emission zones in countries including Germany, Japan and China. All modern light duty diesel vehicles contain a DPF.

79. A DPF is a filter that captures and stores particulates in the form of soot. It is therefore designed to significantly decrease PM in the exhaust gas of a diesel engine before it is emitted from the tailpipe. Such filters use a honeycomb-like lattice to trap particulate matter as the exhaust flows through it. During use, soot will accumulate on the filter. To allow continued efficient operation, the accumulated soot needs to be regularly removed by being burnt off.

80. DPFs encounter similar issues to the NOx capture systems – over time the trapped particles will accumulate. This can lead to increased backpressure with consequential impacts on engine behaviour (e.g. increased fuel consumption/CO_2 emissions). In order to control the mass of PM accumulated in the DPF and therefore prevent the backpressure becoming excessive, the stored PM must be removed through "regeneration" either passive, without EMS intervention or active, in which the EMS has to increase the exhaust gas temperature entering the DPF.

81. "Passive regeneration" occurs during normal vehicle operation and use if and when the filter reaches high temperatures, for example through driving at reasonably sustained high speeds on an A road or motorway. Particulate matter will however accumulate in the DPF if there is regular driving at low speed, for example during regular urban driving at low speeds and/or on congested roads. To combat such accumulations, periodic

"regenerations" of the DPF (known as "active regeneration") are required. This is achieved through using increased amounts of fuel and/or changed fuel injection timing to burn off the accumulated soot. Such active regenerations, which are again controlled by the ECU, create a rapid and severe rise in temperature in the catalytic converter and a spike in fuel consumption, CO_2, NOx and particulate matter emissions from the engine. The frequency of active regeneration will be a function of the EGR rate as well as personal driving patterns: a higher EGR rate (and greater NOx reduction) will result in more frequent DPF regeneration, all other things being equal. This also leads to increased engine noise, another unwelcome by-product related to high EGR rates from an engineering/sales perspective.

82. Due to their low frequency, DPF regeneration events usually do not normally occur during certification tests like WLTP and NEDC. To account for this, specific factors, one for each regulated emission and CO_2, are applied in the certification process. These are known as a "Ki Factor". These factors are determined by running tests repeatedly over the regulated emissions cycle to determine the frequency and duration of DPF regeneration

Diesel Oxidation Catalyst ("DOC")

83. A DOC is a device that converts, through oxidation, HC, some PM, and CO into water vapour and CO_2. The DOC is also used during active regeneration of the DPF to oxidise excess HC in the exhaust gas, generating an exothermic reaction to achieve the additional temperatures required for active DPF regeneration. Finally, the DOC oxidises some of the NO to NO_2 – the ratio of these two gases influences the operation of the SCR. The NO_2 produced by the DOC is partially used for passive DPF regeneration.

84. The DOC supports the function of other emissions control components within the engine such as the DPF and the SCR, and will be positioned upstream of these components. On vehicles fitted with an LNT, the function of the DOC may be performed by the LNT and therefore a DOC may not be fitted.

Engine Control Units

85. The Engine Control Unit ("ECU") is a specialised computer that manages the control of a vehicle's engine in "real-time". The ECU runs "firmware" that consists of "software" and a "calibration". The ECU's firmware coordinates the behaviour of the ECS. The ECU's firmware can generally be divided into three components:

    i) Bootloader: the code that controls the system start-up and some very basic functions;

    ii) The "software": an interdependent set of functions that determine what a system can do, for example injecting fuel or opening and closing the EGR valve;

    iii) The "calibration": which define the values of each calibratable variable (parameter or "label"), including maps, curves and individual values, that are the inputs to each function in the software.

86. In summary, the software defines the mathematical operations of the firmware, while the calibration defines the values used in those mathematical operations.

87. The ECU receives signals (directly or indirectly) from Sensors and feedback from Actuators. Based on this data received from the Sensors and Actuators, the ECU generates and/or adjusts signals sent to the Actuators which influence the vehicle behaviour. In addition to values from the calibration, the software functions also use both measured and modelled values. Measured values are based on Sensor and Actuator signals (potentially with minor adaptations). Modelled values are calculated approximations of values that cannot be directly measured, that are based on knowledge of the engine architecture and functionality.

88. One of the facts which has become very apparent through the evidence in this trial is the complexity of engine operation. Within the engine control software, there are tens of thousands of calibratable parameters, which impact all aspects of the powertrain function, including performance, driveability, durability, on-board diagnostics ("OBD"), safety, noise emissions and pollutant emissions. It is not possible to calibrate responses to every possible permutation of operating point and ambient condition. It is therefore common to have base maps that interpolate between a limited number of calibrated operating points (i.e. not every single operating point is calibrated directly or individually). Ultimately therefore many of these parameters are calibrated by reference to curves or maps, which are arranged to span the full range of operating points and ambient conditions expected to be experienced by the engine. Calibrations must be tuned to ensure satisfactory vehicle operation under a wide range of conditions, including, inter alia, driver behaviour (e.g. how rapidly the accelerator pedal position is changed), the environment (e.g. ambient temperature, altitude, humidity), and the vehicle hardware (e.g. the number of cylinders) and other physical properties of the vehicle to which the calibration is applied.

Engine development: the timeline

89. One part of the Contested Agreed Technical Document which was not agreed was the section dealing with engine development. While this was not ever agreed, it did not appear at trial that there was much in the way of positive disagreements with it. Accordingly, I make the following findings, which are largely drawn from the Defendants' text in that document. It should be borne in mind that they are background matters, and are not designed to specifically design any single manufacturer's processes but to provide a high level overview of the process which may at points be relevant to the issues which arise.

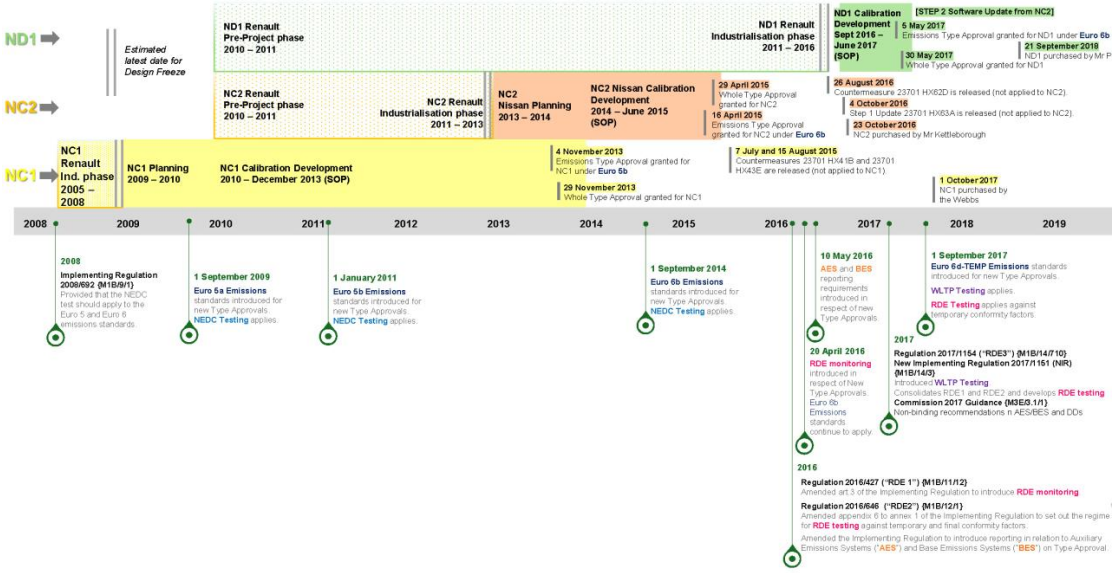
90. The development process for a new engine is usually divided into phases and typically takes some years. It is common for each of these phases to culminate in something called a "design freeze". This is the point in time after which changes to the relevant hardware, technology, system, component or calibration (as applicable) can no longer be made without jeopardising an engine's or vehicle's development timeline. Typically, an OEM will not start substantial volumes of work on the next phase of development until the design freeze for the previous phase is put in place.

91. Similar development phases and design freezes apply to the development of an updated iteration of an existing engine and for a "clean sheet" development process (i.e. starting a completely new product development, whether engine or vehicle, from scratch). The development of the hardware as part of a clean sheet development process is typically divided into at least a concept phase and a definitive phase (although terminology may vary). Each of these phases culminates in a design freeze. During the concept phase, the

OEM determines the basic layout and configuration of the engine, the hardware to be used, the approach to emissions control, and the basic types of technology to be applied to meet targets on matters such as performance, emissions, fuel economy and cost.

92. During the definitive phase, the specific details of how the selected technologies are to be applied and packaged into the engine are established, specific suppliers are selected and the transfer of the hardware from prototype stage to high volume industrialisation is executed. In parallel with the latter stages of hardware design, the engine control software is designed and developed. Once the definitive phase design freeze is in place, the engine control software can be finalised and is ready to be calibrated. The engine control software design and development phase culminate in a further software design freeze whereby the chosen software strategies are "locked in". Similarly, there will be a final calibration freeze where the key engine and emissions control parameters are "locked in" ready for type approval testing. The final calibration of the software may be done by the OEM group itself, or external engineering service providers.

93. An example in chart form was given by Nissan, as follows (covering only some of the Nissan samples):



94. This illustrates in some detail what was going on "backstage" at Nissan in the years prior to these vehicles being sold. One can see, for example that while a vehicle NC1 may have been purchased in 2017, its type approval was granted in 2013 and that the design freeze locked pre-calibration decisions for compliance with the Euro 5 standard into place by the end of 2008.

BACKGROUND

The development of the regulatory framework

95. This is an area which was helpfully and authoritatively outlined by Ms Howard KC in opening. The following section draws on that opening but includes conclusions as to certain points which were contentious and are relevant to the background of the current regulatory regime. There will be issues later as to which of these documents is admissible

for the purposes of construction of the relevant articles of the regulations; but the story of the regulatory development is best told in a fairly linear fashion.

Type Approval

96. At the general level the EEC Type Approval regime was established by Council Directive 70/156/EEC. It was introduced to address barriers to the functioning of a common market arising from differential vehicle regulation. This was replaced by the Framework Directive ("FD"), which operated in substantially the same fashion, with the Commission Directive 77/102/EEC ("Old Emissions Directive") being replaced by the Emissions Regulation ("ER") as the operative "regulatory act" working within the FD'S EU TA framework.

97. Each EU Member State ("MS") must appoint or establish a Type Approval Authority ("TAA") to deal with matters relating to type approval ("TA"). Each Member State is empowered to grant TA to vehicle types submitted to its TAA for supply to market throughout the EU. TA is granted by the issue of a TA Certificate.

98. TA can only be granted by a TAA if the vehicle type complies with all applicable regulatory acts. The manufacturer must ensure that the vehicles, systems, components and separate technical units which they manufacture and place on the market have been manufactured and approved in accordance with those requirements and regulatory acts and must ensure conformity of production.

99. Critically, the ER enables a form of type approval for emissions systems, an Emissions Type Approval or "ETA" which may be used in a family of different models with the same basic characteristics (engine size, fuel type, ECS components) to authorise vehicles with immaterial differences (left or right hand drive, instruments marked in metric or imperial speeds, different seat configurations etc).

100. For mass manufactured vehicles (i.e. those not benefiting from individual TA) all vehicles to be supplied to the market must have a valid certificate of conformity ("CoC") certifying to the owner that it has been manufactured in accordance with all the applicable requirements for applicable EU TA issued (prior to 1 September 2020) pursuant to the FD and (now) pursuant to the Framework Regulation ("FR"). Typically this is done by assembling all the different systems type approvals required (emissions, seat belts, steering wheels): see KBA Judgment at *Cavallari v Mercedes* [2024] EWHC 2904 (KB) (the "KBA Judgment") at [70]. A CoC must be issued before a car can be registered for driving in the EU/UK and is generally provided to the buyer of a new vehicle upon its delivery.

101. If, following the issue of TA, the competent TAA finds that a vehicle with a CoC does not conform to the type that it has approved (most obviously because it contains a PDD), then the TAA is empowered to take necessary measures including, where necessary, withdrawal of TA, to ensure that production vehicles are brought into conformity with the approved type. The TAA (or, after 1 September 2020, any Member State) must advise the TAAs of other MSs (or, after 1 September 2020, the MSs and the Commission) of the measures taken.

102. Limits on NOx levels were first laid down in EU law by the Old Emissions Directive, which added them to the requirements to obtain TA set out in the 1970 TA Directive, in

1976. This full harmonisation was taken to protect human health from nitrogen oxides. In Recital (5) to the relevant amending directive, Directive 77/102/EEC, the EU legislator stressed that "*it is essential that [NOx] emissions…from motor vehicles should be restricted with immediate effect in order to establish a basis for coherent Community action to reduce the limits of the three pollutants [NOx, CO and unburnt hydrocarbons]…*"

Initial Emissions Regulations

103. But in parallel there was the first consideration of emissions. That came in Directive 70/2020/EEC and related to gaseous pollutants – i.e. carbon monoxide and hydrocarbon. The Directive set emissions standards, being the maximum acceptable limit for various pollutants, and prescribed tests which vehicles had to pass to demonstrate those standards had been met.

104. At this stage NOx was not in the eye of the regulator. That point did not arrive until 1977 with Directive 77/102 when the *"latest scientific progress"* led to a redefinition of "*gaseous pollutants"* as "*carbon monoxide, hydrocarbons and nitrogen oxides, the latter expressed as nitrogen dioxide (NO2) equivalents.*" Limits were set between 10 and 16 g/L^2 albeit with a phased introduction allowing 1.25x these figures until October 1979 for certain vehicles.

105. Limits for carbon dioxide and particulates then came in in the 1980s via Directives 88/436 and 91/441.

106. Not unnaturally concerns about climate change and greenhouse gases led to considerable focus on CO_2 emissions. That, and the history of the regulations is set out in Directive 94/12/EC:

> "Whereas Council Directive 70/220/EEC (5) which deals with the measures to be taken against air pollution by emissions from motor vehicles, is one of the separate Directives under the type-approval procedure laid down by Council Directive 70/156/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers (6);
>
> Whereas Directive 70/220/EEC lays down the limit values for carbon monoxide and unburnt hydrocarbon emissions from the engines of such vehicles; whereas these limit values were first reduced by Directive 74/290/EEC (7) and supplemented, in accordance with Commission Directive 77/102/EEC (8), by limit values for permissible emissions of nitrogen oxides, whereas the limit values for these three types of pollution were successively reduced by Commission Directives 78/665/EEC(9), 83/351/EEC (10) and 88/76/EEC (11), whereas limit values for particulate pollutant emissions from diesel engines were introduced by Directive 88/436/EEC (12) whereas more stringent European standards from the emissions of gaseous pollutants of motor vehicles below 1400cm3 were introduced by Directive 89/458/EEC(13) whereas requirements relating to the evaporative emissions and to the durability of emission-related vehicle component as well as more stringent particulate pollutant standards for motor

vehicles equipped with diesel engines were introduced by Directive 91/411/ECC (1).

Whereas, in the light of the worrying level of pollution caused by vehicle emissions and their role in the formation of the gases responsible for the greenhouse effect, it is necessary to reduce emissions, in particular CO2 emissions, whereas CO2 results directly from the combustion of carbon-based fuels, whereas CO2 emissions can principally be reduced by lower fuel consumption…"

107. This approach and a move towards a multifaceted approach led to Regulation 715/2007 which introduced the Euro 5 and Euro 6 standards with which this case is concerned.

108. From 1992 the Euro 1 Emissions standards were imposed. They applied to new passenger car type approvals from 1 July 1992, with limits for HC+NOx (combined) and PM, verified by the ECE15 standardised lab based dynamometer test. The Euro 2 standards reduced the limits for HC+NOx and PM for new type approvals from 1 January 1996, verified by the same test.

109. The Euro 3 and Euro 4 standards were introduced under Directive 1998/69/EC, amending Directive 70/220 ("Directive 98/69"). Euro 3 limits applied to new type approvals from 1 January 2000. The stricter Euro 4 limits applied from 1 January 2005. Euro 3 and 4 constituted "significant steps" in the tightening of vehicle emissions regulations. In particular:

    i) These were the first to impose specific limits on NOx emissions in diesel cars.

    ii) The New European Driving Cycle ("NEDC") test was introduced to regulate compliance with the Euro 3 and Euro 4.

    iii) It introduced minimum standards for OBD systems, "*with a view to permitting an immediate detection of failure of anti-pollution vehicle equipment*" and facilitating maintenance for in-service vehicles.

    iv) The concept of a "defeat device" and what we now recognise as the Article 5(2) exceptions were first introduced.

110. As to the genesis of the defeat device definition, the first origins can be found in the USA. As noted in *Crossley 1* [83]-[93], the US Clean Air Act 1963 introduced emissions standards to the US vehicle market which included a reference to a prohibition on bypassing or defeating emissions control systems. By 1972 the US Environmental Protection Agency ("EPA") had identified the need to prohibit the use of defeat devices.

111. Part 86 of the Electronic Code of Federal Regulations ("Part 86") provided the first definition of a defeat device as:

"Defeat device means an Auxiliary Emissions Control Device ("AECD"): any element of design which senses temperature, vehicle speed, engine RPM, transmissions gear, manifold vacuum, or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system] that reduces the effectiveness of the emission

control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use, unless:

(1) Such conditions are substantially included in the Federal emission test procedure;

(2) The need for the AECD is justified in terms of protecting the vehicle against damage or accident;

(3) The AECD does not go beyond the requirements of engine starting."

112. On 18 June 1996, the Commission had proposed measures to amend Directive 70/220/EEC following the Auto/Oil Programme, by which the European oil and automobile industries participated in a collaborative programme intended to produce a solid technical foundation upon which the Commission could build its strategy for regulating emissions. The definition of a DD first appeared in an amendment to this Commission proposal introduced by Rapporteur Lange on behalf of the Committee on the Environment, Public Health and Consumer Protection of the European Parliament in his report dated 24 March 1997.

113. In subsequent submissions to the Committee of Inquiry into Emission Measurements in the Automotive Sector ("EMIS"), in 2016, Mr Lange gave his recollection thus:

"[after On-Board Diagnostic systems ("OBDs") were introduced] …the focus shifted to the risk of manipulative defeat devices. It has been known that automotive manufacturers with modern electronic equipment are able to recognize the test cycle and to adjust the efficiency of the exhaust gas purification accordingly (defeat devices). Such software was for example used by six manufacturers of trucks in the United States in the early 1990s, to circumvent the EPA's requirements. Also, two European manufacturers were among them: Volvo and Renault. As a final result, NOx emissions were increased 300 times when in operation. But the EPA also inquired against Honda and Ford in 1998, because they had installed defeat devices, which switched off the emission control system from the normal functioning.

For this reason, I introduced Amendment 42 to prohibit such defeat devices."

114. The operative prohibition of defeat devices was then introduced by amendment in the section of Annex I of Directive 70/220/EEC headed "Requirements and Tests", which sets out that (i) the requirement for manufacturers to ensure that emissions were effectively limited was deemed to be met if the provisions related to TA were complied with; and (ii) "*the use of a defeat device is prohibited*". The term defeat device was defined for these purposes as follows, in terms which are strikingly similar to the US definitions:

"2.16. "Defeat device" means any element of design which senses temperature, vehicle speed, engine RPM, transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use.

> Such an element of design may not be considered a defeat device if:
>
> I. the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle, or
>
> II. the device does not function beyond the requirements of engine starting, or
>
> III. conditions are substantially included in the Type I or Type VI test procedures."

115. The definition of defeat device ultimately adopted was in slightly different terms to the original proposal put forward by Mr Lange. Differences include (i) "*element of design*" versus "*component*", (ii) "*senses*" versus "*measures*", (iii) "*for the purpose*" versus "*with a view*" to and (iv) the broadening of the first category of justification to include "*for the safe operation of the vehicle".*

116. The EP Committee draft report on the proposal and the amended proposal for a European Parliament and Council Directive relating to measures to be taken against air pollution by emissions from motor vehicles and amending Council Directives 70/156/EEC and 70/220/EEC Explanatory Statement, already saw issues with the testing regime, saying at pp.68, 71;

> "now that anti-pollution measures have largely been taken in respect of new vehicles, the focus is increasingly turning to the durability of anti-pollution systems and realistic test conditions. This is where the main potential for reducing emissions now lies…
>
> II. Anti-pollution devices must take effect as soon as possible in practice, therefore including short trips and low temperatures. At the moment, conditioning for the test involves a room temperature (20-22ºC) which is unrealistic in everyday life. … This means that in practice engines run at much lower temperatures than in the test cycle. Moreover, in built-up areas most trips are of less than 3 kms, which means that the engine never reaches the test cycle temperature. As catalysers currently fitted to petrol engines work only after a certain temperature is reached (150-200ºC), they are hardly effective at all with cold engines and short trips. 80-90% of pollutants in the current entire test cycle are produced in the first 4 kms; the catalyser does not begin to work until then. In practice, with cold engines and short trips this percentage is increased still further. Manufacturers will of course design their vehicles to meet the test cycle. The result is that there are vehicles which can meet very strict values in the test cycle but at lower temperatures are far more polluting than ordinary vehicles. Some increases in limit values are technologically based and have to be accepted. However, values at -7ºC 10-20 times higher than for the +20ºC test cycle are unacceptable. These principally involve CO and HC. Cold-start behaviour in the urban cycle must therefore also be tested and limits set. Any real reduction covering also low temperatures will improve urban air quality."

117. The regulation explicitly acknowledged the need to "*to take into account the implications for markets and manufacturers' competitiveness, the direct and indirect costs imposed on business*" alongside the benefits that would accrue to (inter alia) health and the

environment. It set out limits for a wide range of pollutants including carbon monoxide, hydrocarbons, nitrous oxides, combined hydrocarbons and particulates.

118. There was some discussion at trial as to regulation for carbon dioxide. The Claimants' approach was to dismiss carbon dioxide as being outside the main emissions regulations and essentially unregulated. However, that is not an entirely fair approach. Carbon dioxide was separately regulated via Regulation 443/2009 as part of the EU commitment to significant reductions in CO_2. The approach taken was not one of limits per car, but as average rates of emissions over a manufacturer's new car fleet. The regulation introduced a three year transition towards the target figures. It also signposted further reductions in future, which have indeed eventuated in the years which have passed since.

The backdrop to the current regulatory regime

119. In the early 2000s the Clean Air For Europe initiative expressed the goal of minimising diesel pollution related deaths by the reduction of (amongst others) NOx and particulate matter emissions. That in turn led (amongst other legislative instruments tackling air pollution) to Regulations which required the progressive tightening of emissions limits for motor vehicles, one of the principals and most ubiquitous sources of NOx and particulate matter emissions.

120. This led to the introduction of the EU Whole Vehicle Type Approval, which consists of a series of regulatory acts addressing the potential safety and environmental dangers posed by vehicles by a series of harmonised standards set topic by topic (such as seat belt or airbag safety specifications), gathered together and given effect by theFramework Directive (Directive 2007/46/EC, "FD") which replaced the old Directive 70/220 as the operative "regulatory act" working within the Directive's EU TA framework. Since 1 September 2020, that has been supplemented by the Framework Regulation (Regulation 2018/858, "FR"). The latter, with modifications, survives as "retained direct EU legislation" by dint of s.3 of the European Union (Withdrawal) Act 2018, and as "assimilated direct legislation" from 1 January 2024.

121. All large series motor vehicles sold in the EU at all material times covered by the NOx Emissions Litigation have required approval under this regulatory regime as regards their emission performance for two specific pollutants: NOx and particulate matter.

122. The applicable standards for vehicles are contained in Regulation 715/2007 (the "Emissions Regulation") which set pollutant limits for motor vehicles. Those limits progressively tighten from the limits applicable to Euro 5 vehicles to the later limits applicable to Euro 6 vehicles ("Euro 5 limits", "Euro 6 limits" or together "Emissions Limits"). For diesel vehicles the relevant pollutants are NOx and particulate matter.

The Emissions Regulations

Key Provisions

123. There are certain key provisions of the Emissions Regulation which are particularly in focus at this trial: Article 3(10) and Article 5(2), which have been set out already. However, there are a number of different aspects of the EU regulatory regime which are interlocking.

124. All parties agree that the regime, as a whole, forms the essential background against which the Article 3(10) and Article 5(2) legal issues in this trial must be considered.

125. The salient aspects of that regime include:

    i) Regulation (EC) 715/2007 (the Emissions Regulation or "ER");

    ii) EU Regulation 2018/858 (the "FR") and its predecessor, EC Directive 2007/46 (the "FD");

    iii) Commission Regulation (EU) 2017/1151 (the "New Implementing Regulation") and its predecessor, EC Regulation 2008/692 (the "Implementing Regulation");

    iv) EU Regulation 2020/683 (the "New Documentation Regulation").

126. As is often the case valuable material is to be found in the ER's material Recitals which explain the objective of the new regulatory scheme, which was against the background of the harmonisation approach produced by the Type Approval regime to harmonise technical requirements for emissions and "*ensure a high level of environmental protection*" (Recital 1).

127. The strategy embodied by the ER was to improve air quality. But it was not a siloed approach. Instead it was a joined-up forward-looking strategy as explained in Recital 5:

> "the task of reducing vehicle emissions should be approached as part of an overall strategy. The Euro 5 and 6 standards are one of the measures designed to reduce emissions of particulate matter and ozone precursors such as nitrogen oxides and hydrocarbons.
>
> Achieving EU air quality objectives requires a continuing effort to reduce vehicle emissions. For that reason, industry should be provided with clear information on future emission limit values. This is why this Regulation includes, in addition to Euro 5, the Euro 6 stage of emission limit values.
>
> In particular, a considerable reduction in nitrogen oxide emissions from diesel vehicles is necessary to improve air quality and comply with limit values for pollution. This requires reaching ambitious limit values at the Euro 6 stage without being obliged to forego the advantages of diesel engines in terms of fuel consumption and hydrocarbon and carbon monoxide emissions. Setting such a step for reducing nitrogen oxide emissions at an early stage will provide long-term, Europe-wide planning security for vehicle manufacturers."

128. Recital 5 thus makes clear that this is part of a continuing effort to reduce vehicle emissions and that the intent is to provide a clear way forward covering Euro 5 and Euro 6 – so as to enable the industry to plan.

129. Recital 6 summarises why a reduction in NOx emissions was necessary and why the introduction of progressively stringent limits was required:

> "…a considerable reduction in nitrogen oxide emissions from diesel vehicles is necessary to improve air quality and comply with limit values for

> pollution. This requires reaching ambitious limit values at the Euro 6 stage without being obliged to forego the advantages of diesel engines in terms of fuel consumption and hydrocarbon and carbon monoxide emissions. Setting such a step for reducing nitrogen oxide emissions at an early stage will provide long-term, Europe-wide planning security for vehicle manufacturers"

130. Recital 7 acknowledges the importance of taking into account the effect on markets and the benefits that accrue from stimulating innovation as well as the environmental and health aspects.

131. Recital 10 is also relevant to the topic of ammonia slip. It provides:

> "The Commission should keep under review emissions which are as yet unregulated and which arise as a consequence of the wider use of new fuel formulations, engine technologies and emission control systems and, where necessary, submit a proposal to the European Parliament and to the Council with a view to regulating such emissions".

132. One relevant example of such unregulated emissions is ammonia, the product of urea reagent-based SCR and the subject of the "Ammonia Slip" debate. Ammonia was never a regulated pollutant in Euro 5 or Euro 6 limits (by contrast to HGV emissions legislation which set binding limits for trucks at Euro VI, leading to the use of HGV ammonia slip catalysts); and it was only added to the list of regulated pollutants for cars in Euro 7, which is yet to take effect in the EU.

133. The Recitals go on again to describe more of the way forward – not just regulating as yet unregulated pollutants but tightening up on existing ones – and to find better ways of measuring to be introduced as soon as possible – along with reviewing and potentially replacing the test drive cycle.

134. This is a point of particular importance here because the regime put in place by the Emissions Regulation and the associated Implementing Regulation tested the compliance of the vehicle with the Emissions Limits during a test called NEDC which was intended to operate as a rough proxy for normal driving. That it was a rough proxy and that there was potential for improvement is made amply clear by these latter recitals and will be explained further below.

135. Recital 15 acknowledges the limitations of the NEDC and accepts that it does not capture real world emissions. However, it makes clear that the regulatory tests will need to evolve to ensure that real-world emissions correspond to those measured at type approval:

> "The Commission should keep under review the need to revise the New European Drive Cycle as the test procedure that provides the basis of EC type approval emissions regulations. Updating or replacement of the test cycles may be required to reflect changes in vehicle specification and driver behaviour. Revisions may be necessary to ensure that real world emissions correspond to those measured at type approval. The use of portable emission measurement systems and the introduction of the "not-to-exceed" regulatory concept should also be considered".

136. Recital 16 records the importance of the OBD system in the control of emissions:

"OBD systems are important in the control of emissions during the use of a vehicle. Due to the importance of controlling real world emissions, the Commission should keep under review the requirements for such systems and the tolerance thresholds for monitoring faults".

137. Moving into the body of the Regulation, Article 1 notes the first aim of the Regulation – to establish common technical requirements for the type approval of vehicles with regard to their emissions as well as rules for in service conformity. Article 2 covers scope (the types of vehicles to which it applies) and Article 3 definitions.

138. The central obligation is that in Article 4: "Manufacturers' obligations". Manufacturers are required:

139. Under Article 4(1) ER, to demonstrate that all new vehicles sold, registered or put into service are type approved in accordance with the regulations and their implementing measures. The article goes on to say, "*These obligations shall include meeting the emissions limits set out in Annex I*".

i) Annex I sets out the limits for a range of emissions specified by vehicle type. This covers NOx but also carbon monoxide, hydrocarbons and particulates:

ANNEX I

EMISSION LIMITS

Table 1

Euro 5 emission limits

		Reference mass (RM) (kg)	Limit values													
			Mass of carbon monoxide (CO)		Mass of total hydrocarbons (THC)		Mass of non-methane hydrocarbons (NMHC)		Mass of oxides of nitrogen (NO_x)		Combined mass of total hydrocarbons and oxides of nitrogen (THC + NO_x)		Mass of particulate matter (PM)		Number of particles [1] (P)	
			L_1 (mg/km)		L_2 (mg/km)		L_3 (mg/km)		L_4 (mg/km)		$L_2 + L_4$ (mg/km)		L_5 (mg/km)		L_6 (#/km)	
Category	Class		PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI [2]	CI	PI	CI
M	—	All	1 000	500	100	—	68	—	60	180	—	230	5,0	5,0		
N_1	I	RM ≤ 1 305	1 000	500	100	—	68	—	60	180	—	230	5,0	5,0		
	II	1 305 < RM ≤ 1 760	1 810	630	130	—	90	—	75	235	—	295	5,0	5,0		
	III	1 760 < RM	2 270	740	160	—	108	—	82	280	—	350	5,0	5,0		
N_2			2 270	740	160	—	108	—	82	280	—	350	5,0	5,0		

ii) Under Article 4(2) ER, there is an obligation to ensure that *"tailpipe emissions .... are effectively limited .... throughout the normal life of the vehicles under normal conditions of use"*. (Article 3(6) IR is to like effect). The latter phrase is similar to but not identical to the fuller expression "*under conditions which may reasonably be expected to be encountered in normal vehicle operation and use*" employed by Article 3(10) ER;

iii) Article 4(2) ER goes on to make provision for "*in-service conformity checks*" and the durability testing of pollution control devices, the detail of which are supplied by the IR (see Article 4(4) ER). This is part of a clear objective to control emissions throughout the vehicle's life (which varies for in service conformity compared to durability), such that: (i) it must be able to pass a test of in service conformity (using a NEDC type 1 test) at any time in that life; and (ii) deterioration in the efficiency of the emissions control system over that life must be captured and modelled (by a DF factor) and used to adjust raw NEDC figures when assessing

compliance with the emissions limits. Fuel consumption and carbon dioxide emissions are required to be set out in a document given to the purchaser.

140. Manufacturers are then specifically obliged under Article 5(1) ER, to equip vehicles so that *"components likely to affect emissions"* are designed, constructed and assembled "*so as to enable the vehicle, in normal use*" to comply with regulations and their implementing measures. There is no specific obligation, but this effectively reinforces the requirement for in service conformity under "normal conditions of use" in Article 4(2) and is the springboard for the specific obligation found in Article 5(2).

141. Article 5(2) then expressly prohibits "*the use of defeat devices that reduce the effectiveness of emissions control systems*", subject to three limited exceptions.

142. Such defeat devices are defined by Article 3(10), as:

> "any element of design which senses temperature, vehicle speed, engine speed (RPM), transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use".

143. The three exceptions which may "justify" the existence of a defeat device are provided for by Article 5(2) (the "Article 5(2) Exceptions"):

    i) The engine protection and safety justification under (a), where "*the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle*";

    ii) The engine start justification under (b), where "*the device does not function beyond the requirements of engine starting*"; and

    iii) The "substantially tested" justification under (c), where "*the conditions are substantially included in the test procedures for verifying evaporative emissions and average tailpipe emissions*". This justification only makes sense if the PDD definition reaches into what would otherwise be off cycle strategies.

144. The use of a PDD is thus a specific form of breach of Article 5(1) and 4(2) ER.

145. These test results then feed into the grant of TA and the issuance of the CoC, certifying that the relevant vehicle has been produced under the same production processes and systems as an example of the type which has achieved TA and has thereby complied with all applicable regulatory acts, including the Emissions Regulation. The CoC contains details of (amongst other things) the vehicle's fuel consumption profile as tested in the TA;

146. The emissions so measured were then adjusted by two factors, the ki Factor and DF factor, to model (respectively) the increased emissions flowing from DPF regeneration (a function of the EGR rate) and from the deterioration in efficiency of the ECS over the expected 160,000 km lifespan of the vehicle (itself affected by how they are stressed by

operation over time, more frequent DPF regeneration being liable to wear out the DPF sooner). Both ki Factors and DF factors are measured using key inputs provided by manufacturers, not least the expected distance between DPF regenerations (the D number).

Testing Regimes (NEDC and others)

NEDC

147. As noted above, in the context of Euro 3 and Euro 4 emissions regulations the NEDC test was introduced. A key fact necessary to understand the expert evidence is that the NEDC was and is conducted in laboratory test conditions at standardised air temperatures using standardised driving phases on a dynamic roller (which imitated the speeds and loads on a variety of roads) during which the emissions of pollutants, such as NOx and particulate matter, are measured.

148. The history of the test is lengthy and is capable of being contentious. However, that history is not relevant. What is clear, and agreed, is that the NEDC test:

    i) Is a chassis dynamometer (as opposed to an "on road") test. It is performed in a laboratory;

    ii) The vehicles are subject to a preconditioning comprising:

    iii) A preparatory drive – involving the vehicle being driven through the extra-urban cycle of the NEDC three times at most 36 hours, and at least 6 hours, before the NEDC test proper;

    iv) A soak-period – after the preparatory drive and before the NEDC test proper, the vehicle is kept in a room in which the temperature remains relatively constant between 293K (20°C) and 303K (30°C). This soak-in period should last for at least six hours and continue until the engine oil temperature and coolant, if any, are within +/- 2K of the temperature of the room.

149. The NEDC also takes place within certain other conditions and parameters, which are relevant to the allegations made:

    i) Ambient temperature: the test cell temperature should be between 293K and 303K (20°C and 30°C);

    ii) Humidity: the absolute humidity (H) of the air in the test cell or the intake air of the engine should be such that humidity lies within the range between 5.5g and 12.2 g H^20/kg dry air;

        a) A detail which takes on significance later is that on the NEDC test, IAT will always be equal to or above 17°C. This is because the vehicle must be pre-soaked to an ECT within 2ºC of the ambient temperature of 20-30°C, meaning the lowest temperature at the start of the test is 18°C;

        b) The test lasts about 20 minutes. It comprises an "urban driving cycle" with speeds no higher than 50km/h and frequent stops designed to mimic driving conditions in cities. That is repeated 4 times. Part 2 comprises an "extra

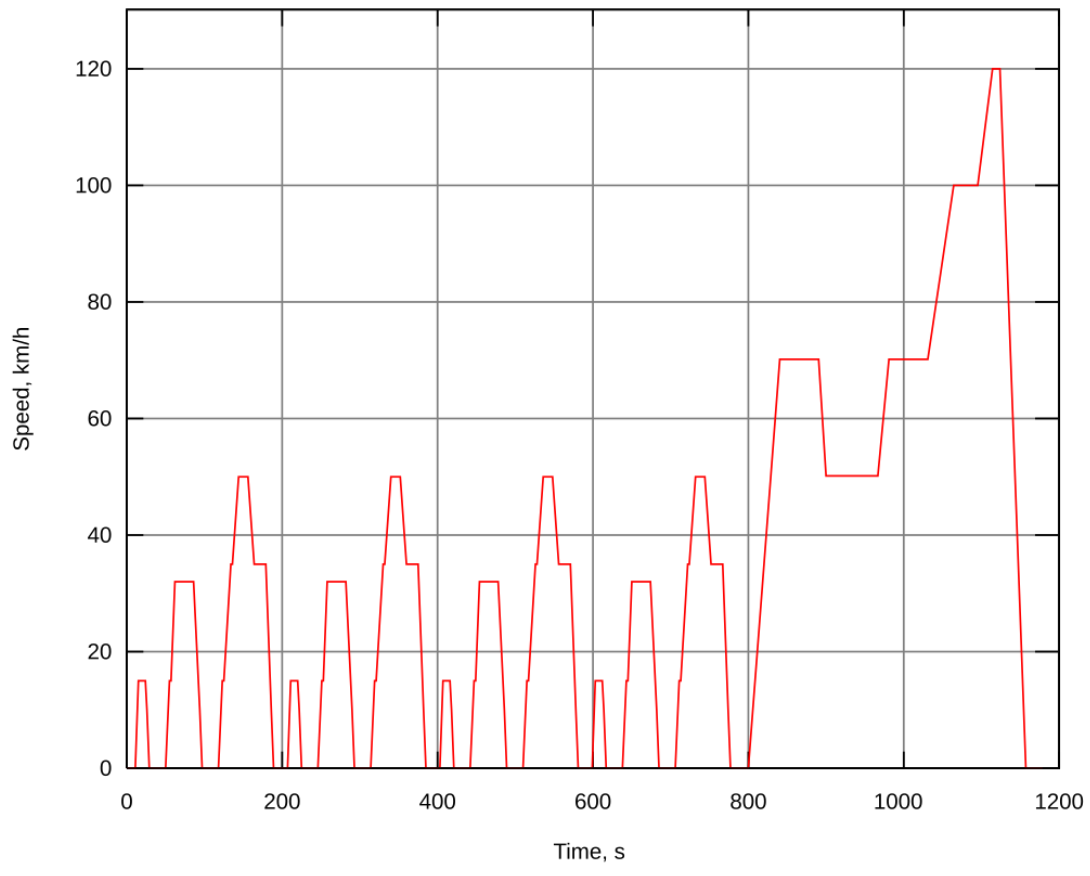
urban driving cycle" designed to mimic higher speed driving modes – but straight, on a flat road with moderate acceleration and a short maximum speed of 120km/h;

iii) Each urban cycle has a duration of 195 seconds, with a specified pause in between. For each operating cycle, there are then three separate operating curves with precisely specified time and speed: the first up to 15 km/h, the second up to 32 km/h, the third up to 50 km/h and, with decreasing speed, some seconds at 35 km/h. The distance covered is 4.052 kilometres, the maximum speed is 50 km/h, and the total running time is 13 minutes (4 phases x 195 seconds = 780 seconds);

iv) In the extra urban cycle, the driver accelerates to 70 km/h and continues at that speed for a specified number of seconds. Then the driver reduces the speed according to the driving line displayed on the monitor to 50 km/h and continues at that speed for a period again specified to the second. The driver then accelerates again to 70 km/h, remains at the line displayed on the monitor for 42 seconds, then further accelerates to 100 km/h and, after a short time, to 120 km/h, and then rapidly reduces speed to 0 km/h. The distance covered is 6.955 kilometres, the maximum speed is 120 km/h and the total running time is 400 seconds.

v) Besides the speeds to be driven, the cycle also includes prescribed gear settings, for use when testing vehicles with manual gearboxes. This is relevant in this case, because in cars with a Gear Shift Indicator the use of the sixth gear at the relevant point is contraindicated, and that gives rise to one of the alleged PDDs.

150. The "trace" of an NEDC test looks like this:



151. The main cycle characteristics of the NEDC are:

i) Running time: 19.66 minutes (1,180 seconds);

ii) Distance: 11.007 km;

iii) Max speed: 120 km/hr;

iv) Average speed: 32.5 km/hr;

v) Max acceleration: 0.833 m/s^2;

vi) Max deceleration: -1.3898 m/s^2.

152. Emissions collected during each NEDC test cycle are collected in a sample bag, or for particulates, on a filter. They are averaged over the distance of the test to produce a value in milligrams per km. The procedure provides for an average of three sets of NEDC results (although only one or two tests may be required if certain criteria are met). It is permitted to exceed the applicable Type I emission limit by up to 10% in one of the three tests provided that the arithmetic mean is below the relevant limit.

153. The results obtained from the NEDC test are multiplied by a Ki factor for each pollutant (if the vehicle has a periodically regenerating system, such as a DPF) and deterioration factor. It is the averaged milligram per km test results, with the Ki factor for each pollutant and deterioration factor applied, that are required to meet the Type I emission limits specified in Annex I to the Emission Regulation. For Euro 5 or Euro 6 vehicles for NOx, these are

i) Euro 5 class M: 180mg/km;

ii) Euro 6 Class M: 80mg/km;

iii) Euro 5 category N1 class III: 280 mg/km;

iv) Euro 6 category N1 Class III: 125 mg/km.

154. As it is an averaged result, it is permissible for emissions to exceed the relevant emission limits for parts of the NEDC test. These limits apply only in the NEDC test.

RDE

155. There was a general acceptance that the NEDC was a blunt instrument and did not accurately replicate or even provide a robust proxy for real world driving. For example, the Ford mechanical engineering experts agreed that "*The Test does not cover all real world driving and, hence, does not exercise the ECS over its full range of operation*." Accordingly, from 2016 the EU regulatory regime moved towards more sophisticated tests.

156. One of these was the Real Driving Emissions test ("RDE"). RDE testing was introduced in a stepped approach: from 20 April 2016, RDE monitoring was introduced in respect of new Type Approvals, and from 1 September 2017 it was mandatory for RDE Tests to be performed and the results made available when conducting new Type Approvals..

There was then a gradual roll out of quantitative emissions requirements, subject to what were called "conformity factors" which have tightened over time.

157. The RDE uses a Portable Emissions Measurement System ("PEMS") attached to a vehicle's exhaust to measure emissions in (defined) real-world driving conditions. One issue in the evidence has been the extent to which PEMS devices were realistically available at the relevant times for the purposes of these vehicles.

158. Since RDE tests are conducted on the road under traffic conditions, there is no specific cycle driven as is the standard under NEDC and WLTC. Instead, the legislation sets out the "shares" of urban, rural and motorway driving of which a valid RDE test must consist. Specifically:

    i) The trip must consist of approximately (i.e. ±10 percentage points) 34% urban, 33% rural and 33% motorway driving;

    ii) Vehicle velocity should normally not exceed 145 km/h, though this may be exceeded by a tolerance of 15 km/h for no more than 3% of the duration of the motorway driving;

    iii) The average vehicle velocity (including stops) of the urban driving part of the trip should be between 15 and 40 km/h, and stop periods should account for 6 to 30% of the duration of the urban driving part of the trip;

    iv) The vehicle velocity range during motorway driving should cover between 90 and at least 110 km/h, and the vehicle's velocity must be above 100 km/h for at least 5 minutes;

    v) The duration of the trip should be between 90 and 120 minutes, and the start and end point should not differ in their altitude by more than 100 m;

    vi) Each of the urban, rural and motorway operation parts of the test should be at least 16 km as a minimum distance.

159. The RDE also provides for appropriate temperature conditions – these are wider than the NEDC test temperature window and are considered further under Normal Driving Conditions below.

160. Vehicles are also preconditioned before undertaking an RDE test. Before undergoing a cold-start RDE test, the vehicle must be driven for at least 30 minutes on open roads, and then parked with its doors and bonnet closed, and kept with its engine off for between 6 and 56 hours before the test. When undertaking a hot-start RDE test, the vehicle is to begin the test with a warm engine and engine coolant temperature and/or engine oil temperature above 70°C.

WLTC Test

161. The WLTC is another testing procedure aimed at determining the levels of gaseous pollutants, particulate matter, particle number, CO_2 emissions, fuel consumption, electric energy consumption and electric range from light-duty vehicles in a repeatable and reproducible manner designed to represent real driving conditions as much as possible.

162. The WLTC is split into four speed ranges: low (1), medium (2), high (3), and extra high (4), each corresponding to specific driving conditions. The "low" range represents urban traffic, with a maximum speed of 56.5 km/h. The "medium" and "high" ranges simulate inter-urban and express road driving, with maximum speeds of 76.6 km/h and 97.4 km/h, respectively. The "extra high" range reflects motorway driving, where the maximum speed reaches 131.3 km/h. The following figure illustrates the driving profile for the low, medium, high and extra high speed ranges of the WLTC.

163. The main cycle characteristics of the WLTC are:

i) Distance: 23.266 km;

ii) Max speed: 131.3 km/hr;

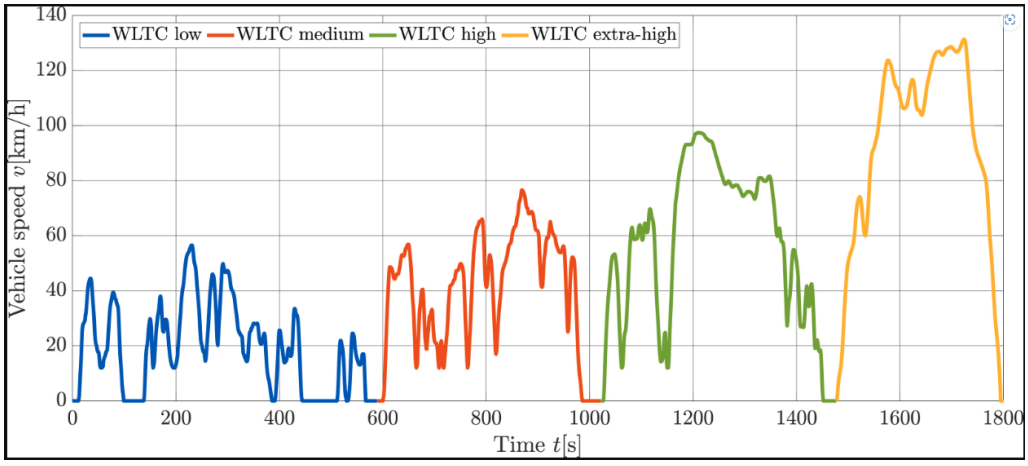
iii) Average speed: 46.5 km/hr;

iv) Max acceleration: 1.58 m/s²;

v) Max deceleration: -1.49 m/s².

164. Besides the speeds to be driven, the cycle also includes rules for gear settings, primarily for manual gearboxes.

165. The WLTC is generally considered to be more reflective of real driving conditions compared to the NEDC with a more dynamic driving style. As with the NEDC, the WLTC sets out vehicle configuration and environmental conditions at which the cycle is carried out; these include ambient temperature (23°C with a margin of ± 5°C; 14°C with a margin of ± 5°C for additional CO_2-Tests), humidity and load settings. Like the other tests it involves a preconditioning phase. In the case of the WLTC, the WLTC involves a preconditioning period before the test proper is carried out. WLTC preconditioning also involves the vehicle being run to a predefined cycle before being put in ambient conditions to "soak" for a minimum of 6 hours and a maximum of 36 hours in an area with a temperature set point of 23°C with a tolerance of +/- 3°C.



Ki Factors and DFs

166. As has been mentioned briefly above a "Ki Factor", is a measurement of the additional pollutant contribution made by the periodic active regeneration of DPFs and additional

catalysts (most obviously, periodic regeneration of the SCR to remove sulphur), where used (as DPFs invariably are), through the vehicle's intended 160,000 km lifespan. A periodic regeneration is one that occurs infrequently, to be contrasted with a system in continuous regeneration i.e. occurring at least once every NEDC cycle (as with, say, the LNT or passive DPF regeneration), and whose effects are thus in principle, but not in practice, caught by the NEDC.

167. Ki Factors are determined by running tests repeatedly over the regulated emissions cycle (i.e. by running back to back NEDC tests until a regeneration occurs) to determine the frequency and duration of DPF regenerations, and the emissions produced during a regeneration. The Ki Factor then produces an adjusting factor (pollutant by pollutant) that effectively smooths the heightened emissions and fuel consumption from these periodic events that is applied to the raw NEDC results.

168. A deterioration factor ("DF") is used to model the lessening efficiency of the vehicle's pollution control devices as a result of wear and tear through its intended 160,000 km lifespan (high temperature regenerations being particular stressing events for DPFs and catalysts). DFs work similarly to Ki Factors based on periodic measurements of emissions at various aged stages of vehicle life.

169. Both the Ki factor and DF:

    i) are calculated using information provided by the manufacturer to the Approval Authority (as well as information from the official tests), in particular the D and d numbers which record how frequently regenerations occur and how long they last, as well as the pollutant emissions produced in a regeneration; and

    ii) appear on the model TA certificate, such that any change thereto requires an amendment in the form of an extension to TA. TA can only be granted if the figures produced by multiplication of the Type 1 test results by the Ki and deterioration factors are less than the applicable Emissions Limits.

170. These factors are principally relevant to the various updates applied by manufacturers, in particular where their effect was substantially to widen the use of EGR. All Lead Defendants have, by way of update from the calibrations originally type approved, made changes to EGR in either Euro 5 or Euro 6 or both, the effect of which updates is substantially to widen the windows in which higher rates of EGR are used. The fact that such updates have been made without any change to Ki Factors or DF, is said by the Claimants to suggest that the supposed risks (clogging/sooting, EGR or DPF part failure etc) have little or no practical effect on ECS component durability/deterioration over time; and that marked increases in EGR have been achieved without any increased frequency of DPF regeneration.

<u>Developments in Regulatory framework</u>

171. While the issues of law and construction must be considered against a background which takes the story no further forward than (at the soonest – see above regarding development freeze) the date of manufacture of the vehicle, a number of processes and procedures which came into effect as part of the later regulatory framework have come into focus at varying points in the argument and require explanation.

AES/BES

172. From May 2016, manufacturers were required to provide information relating to their "base emissions strategy" ("BES") and their "auxiliary emissions strategy" ("AES"). Their definitions are as follows:

    i) A BES is an *"emission strategy that is active throughout the speed and load operating range of the vehicle unless an auxiliary emission strategy is activated*", and

    ii) An AES is "*an emission strategy that becomes active and replaces or modifies a BES for a specific purpose and in response to a specific set of ambient or operating conditions and only remains operational as long as those conditions exist*".

173. Recital 5 to Regulation 2016/646 explains why this further information was required:

> "'Defeat devices' as defined in Article 3(10) of Regulation (EC) No 715/2007 reducing the level of emission control are prohibited. Recent events have highlighted the need to strengthen the enforcement in this respect. Therefore it is appropriate to require a better supervision of the emission control strategy applied by the manufacturer at type-approval …"

174. The "recent events" in question plainly refer to Dieselgate, and the reference later in Recital 5 to the heavy-duty regime is because the AES/BES requirements became part of that regime from 2011 onwards by Euro VI Regulation (EC) No. 595/2009 and its implementing measures.

175. Article 5(11) IR (as amended) states that it was a requirement to obtain Type Approval that a manufacturer provide *"information on the operation of all AES and BES, including a description of the parameters that are modified by any AES and the boundary conditions under which the AES operate"*. When read with the AES/BES definitions, it is apparent that the BES is the main emissions strategy that is active throughout the speed and load operating range of the vehicle, and such a strategy can only be modified by an AES. The Claimants suggest that an AES is thus equivalent to a US AECD and as with an AECD, where it reduces the effectiveness of the ECS during NDC it is a DD that requires to be justified.

176. The requirements of Article 5(11) were subsequently amended to require further particulars to be provided, and, by July 2017, it was a requirement for a manufacturer also to provide a declaration that a vehicle did not contain any PDDs.

177. AES/BES documents were submitted by Mercedes, PCD, Ford and Renault.

178. In January 2017, the 2017 Commission Guidance was published, which reflected discussions with experts from the Type Approval Authorities Expert Group, the Commission and experts from Member States. The stated purpose of the document was *"to set good practices for the assessment of intended engine protection strategies and prevention of illegal defeat devices. For this purpose, it provides guidance on the criteria that should be used by the TAAs in order to evaluate an AES*" (pg. 2). This Guidance was heavily relied on by the Claimants as *"a helpful guide of how the definitions in Arts. 3(10) and 5(2) were to be interpreted even prior to the CJEU deciding any of the cases*

… and it notably demonstrates how narrowly the Commission considers the Article 5(2) justifications should be construed."

179. Section 2 Part A of the 2017 Commission Guidance states that the TAA must assess, on the basis of the technical information provided whether: (i) the emissions control strategy constitutes a DD and, if so, whether (ii) it is justified pursuant to Article 5(2) ER (pg. 6), and identifies the following verifications that must be carried out:

    i) The increase in emissions induced by the AES should be kept to the lowest possible level;

    ii) When used to justify an AES, the risk of sudden and irreparable damage should be appropriately demonstrated and documented including: "proof of catastrophic engine damage" being provided, as well as a risk assessment of the evaluation of the likelihood of risk occurring, supported by test results; and use of best available technology to reduce the risk. It states that durability and long-term protection of the engine are not acceptable reasons to grant the exemption under Article 5(2). In short, generic or hypothetical evidence did not and could not suffice;

    iii) An adequate technical description documenting why it is necessary to use an AES for safe operation of the vehicle (including proof of risk, along with a risk assessment supported by test results). Again, best available technology must be used; and

    iv) Where an AES is used during engine start, best available technology should be used to the largest extent technically possible to avoid unjustified modulation.

180. The document also provides examples of AES (pg. 8), including thermal windows in all their forms (which are by definition "off cycle" only) and guidance on how to recognise a DD, including how testing might be carried out (see p.11) and when results may indicate the presence of a DD, including by reference to multiples of the Emissions Limits in NDC (p.12).

181. The Commission Guidance was updated in 2023.

182. New limit values were set by Regulation 2024/1257 which also prescribes use of the WLTP test.

183. The current (Euro 7) regime is governed by Commission Implementing Regulation 2025/1706. This:

    i) Notes the prohibition of "manipulation devices and manipulation strategies" under Regulation 2024/1257 and the need for "*specific methods, procedures, administrative procedures, reporting and documentation obligations*" to establish the absence of such devices and strategies;

    ii) At para 1.1 of Annex 1 provides that "Manufacturers shall include a technical description of their [base emissions strategy] in the extended documentation package according to Appendix 2";

    iii) Provides at Para 1.5 of the regulation "*Manufacturers may omit any [auxiliary emissions strategy] from the extended documentation package provided they meet*

one or more of the following conditions ... The [auxiliary emissions strategy] does not lead to the exceedance of limit values defined in Annex I of Regulation (EU)2024/1257 while it is active."

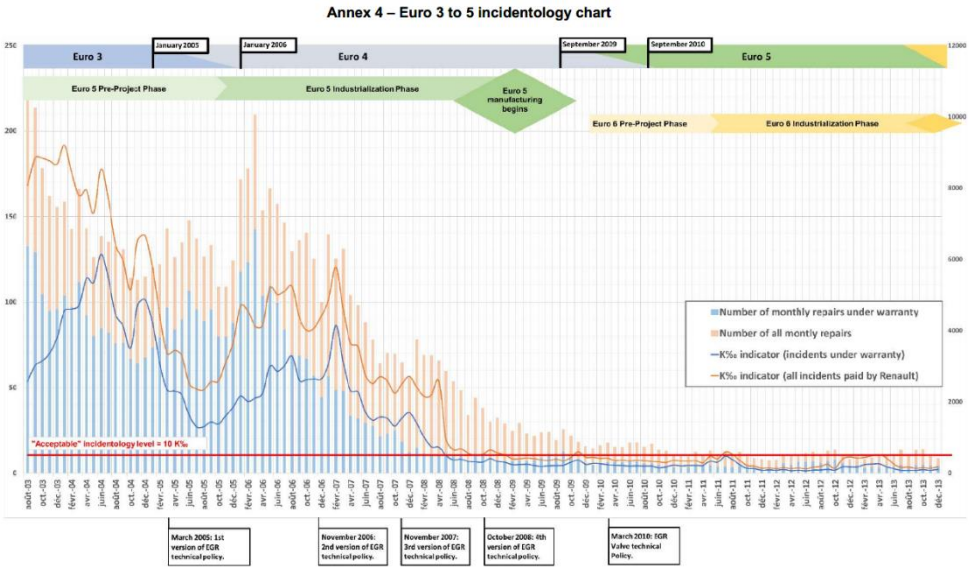
Engineering problems related to justification

184. In the context of justification arguments, a number of the Defendants relied upon problems encountered in real life which were said to have impacted on calibration and to be relevant to questions of justification, if that issue became relevant. The overall themes drawn from these were woven through most arguments on justification.

185. For Renault there was something called "the Incidentology Crisis" encountered in relation to the earlier Euro 3 and 4 vehicles. Following the launch of Euro 3 vehicles in 2003, Renault identified an unacceptable number of serious incidents of engine damage. These continued in Euro 4 vehicles. Approximately 33% of incidents involved a loss of power (plainly a significant danger if that occurred whilst (for example) driving at high speed or overtaking). One example which was given was in Spain in April 2007 where an indicator light went on following the clogging of the DPF. It appears that it was then run on the motorway with no abnormalities observed, but on a second run, there was an explosion and then fire – admittedly while the service team were driving the vehicle ignoring the warning light.

186. Other serious risks such as fire also materialised, vividly illustrated by the incident which occurred during the Tour de France in 2007: a Euro 4 diesel vehicle being used by a journalist to follow the Tour experienced a sudden loss of power and caught fire, due to a clogged DPF. While this particular incident may not have been the best example (given that it was fixed by an in service fix and a new air duct) there is no doubt that there were problems, that they caused Renault grave concern, and that they informed Renault's approach to planning for Euro 5 and 6.

187. Incidents affecting the EGR system (including those in which safety was not compromised) averaged around 6,000 per month between August 2003 and August 2007. The problems were summed up in the following chart:



188. While the Renault Incidentology crisis is the most defined chapter of evidence concerning the kinds of issues and dangers which underpin the Defendants' arguments on justification, it should be taken that all of the Defendants raised similar concerns. Thus:

i) Mercedes led the field on concerns relating to combustion stability, it being common ground that EGR rate modulations necessary to maintain combustion are not DDs. The expert evidence established a portfolio of points about combustion stability (some of which segued into driveability):

a) EGR rate reductions are needed at low ambient temperatures to preserve combustion stability. This is because of the reduced temperature of the charge entering the engine, which can impact combustion stability. This impact can be felt even at 5ºC. There is similarly a need for EGR rate modulation at high temperatures;

b) Reduction in EGR rates at altitude (at atmospheric pressures of between 900 and 950mbar) are acceptable and "*well known in the public literature*", and indeed (at 930mbar) are "*necessary to preserve combustion stability and engine performance soot production, and to prevent driveability issues*";

c) There is a specific need to reduce EGR for combustion stability during engine warm-up;

d) Reductions in the EGR rate can be needed at higher loads to ensure combustion stability and to prevent excessive PM formation, which can itself impact combustion stability.

ii) Ford invoked dangers of lacquering and failure of the EGR valve; high temperatures exceeding component limits; the potential for unexpected or sudden increases in power which could surprise a driver and cause an accident; stalling; fouling of the EGR cooler; poisoning of the LNT and DPF; fire within the aftertreatment system; contamination of the engine oil reservoir with engine fuel causing an unexpected combustion event and a sudden increase in power; damage to the variable geometry turbo ("VGT") which could cause an unexpected and sudden increase in power; and an engine fire due to failure of the EGR cooler.

iii) PCD relied upon (inter alia) overheating damage including EGR cooler cracking; EGR valve failure; coolant overheating; thermal damage to the DPF; piston overheating and engine failure, engine fire through mechanisms such as EGR cooler rupture, excessive temperatures, or uncontrolled DPF regenerations associated with soot build-up. Also invoked were compressor surge, overspeed and engine runaway.

<u>What is not in issue: Legal Issue 4</u>

189. It is worth pausing here to review the very limited common ground there is on the legal position as set out in the regulations.

190. It is agreed (subject to a "marker" by the Claimants as to a contrary determination elsewhere):

i) The Emissions Limits within the ER/IR are limits to be tested in the NEDC test;

ii) The ER/IR requires that the NEDC (adjusted by Ki and DF factors) is passed and results recorded;

iii) The ER/IR requires that vehicles in service can show in service conformity via an NEDC test;

iv) The Emissions Limits do not apply outside the NEDC.

191. It follows that PDD Legal Issue 4, which is: "*Is there an obligation for an OEM to meet emissions limits outside the test cycle*?" can be answered in the negative. The regulations with which this Court is concerned, which applied to these vehicles, did not require the Emissions Limits in the ER to be met off-cycle.

192. It is also worth noting that the ER did not impose an obligation to do better than the test or to do as well as was technologically possible. The obligation is to pass the test to the limits set, and not to include PDDs in the vehicles.

The legal background in overview

193. The issues in this case arise against a backdrop of some (fairly considerable) prior legal consideration in England and Wales, in the CJEU and in other EU jurisdictions. A number of those decisions will have to be considered in depth later in this judgment. Since however they, to some extent, inform the structure and nature of the issues pleaded and argued, some account of them at this stage is needed.

Volkswagen and "Dieselgate"

194. In September 2015, the US EPA issued companies within the Volkswagen Group with a notice of violation under the US Federal Clean Air Act 1963, following an investigation which commenced in 2014 which identified VW's CRDD(DM) installed in its EA189 engines, and which was the subject of *Crossley 1*. The PDD was initially discovered following research conducted by Mr Carder and his colleagues at West Virginia University into real-world driving emissions.

195. This PDD, by using an algorithm that detected whether or not the vehicle was on the set/predictable path of the NEDC, switched the vehicle into an entirely different mode with distinct calibration maps, with a reduced EGR rate operative whenever it was detected the vehicle was not in or no longer in the NEDC. This meant that, say, a vehicle with IAT and torque/acceleration demand consistent with the NEDC in the first few moments of its operation might work in Test Mode; but once acceleration etc. inconsistent with the NEDC, typically after a few seconds, was detected the vehicle would switch out to a second Road Mode with its own calibration maps. This is a classic "*cycle recognition defeat device*" or CRDD.

Regulatory Investigations

UK Department for Transport

196. In April 2016 the UK Department for Transport ("DFT") published a report following the testing of a number of vehicles for the presence of cycle recognition software. The

report's findings were relied upon by the Claimants in their GPOC against each Lead Defendant, but did not form an appreciable part of the trial.

197. The DFT did not find any use by other manufacturers of CRDDs akin to those used in VWs, but it was recorded that many vehicles very substantially exceeded the Emissions Limits during road testing. At §6.4 of the report, it was recorded that "*manufacturers are using a temperature dependent strategy to regulate*" the EGR rate, and were doing so in both older Euro 5 vehicles and also in the "very latest" Euro 6 designs. At §5.29, the generic explanation recorded from the manufacturers was that this was in order to reduce "soot deposits" at low temperatures.

German Federal Ministry of Transport and Digital Infrastructure

198. As part of the "Volkswagen Commission of Inquiry" instigated by the German Federal Ministry of Transport and Digital Infrastructure ("BMVI"), the German Federal Motor Transport Authority, the Kraftfahrt-Bundesamt ("KBA") conducted a field examination of diesel vehicles in late 2015 and published its results in May 2016.

199. A series of vehicles were tested from each manufacturer (including the Lead Defendants), all of which showed that the Emissions Limits were exceeded when the vehicles were tested using variants on the NEDC (for example, run under "hot" conditions). The manufacturers were asked in each case to explain their emissions strategies and justify why the Emissions Limits were exceeded, with the most common response being for component protection reasons.

French Royal Commission

200. The Ségolène Royal Commission in France published a report in July 2016 ("French Commission Report") following testing conducted on diesel vehicles. Explanations were provided by the manufacturers as to why their vehicles exceeded the Emissions Limits, with the common response again being for component protection reasons.

European Parliament Committee of Inquiry

201. Following the VW emissions scandal, an inquiry was conducted by the European Parliament and evidence was taken by way of oral and written evidence. The EU Parliamentary Committee of Enquiry into Emission Measurements in the Automotive Sector produced its report on 2 March 2017. The Claimants rely on the evidence from the manufacturers in the case of both Renault and PCD.

National Forum Diesel

202. Following publication of the DFT, BMVI and French Commission Report, a "National Forum Diesel" (the "Forum") took place in Germany in the summer of 2017. The Forum began as a "dialogue" between Mercedes (and presumably other manufacturers), the KBA and the BMVI in 2015, and the purpose was "*how to ensure NOx reductions in real driving*" (i.e. to reduce off-cycle emissions). It was also a response to the introduction of ULEZ-type schemes by German cities, and proposals for bans of diesel vehicles. The only detailed publicly available information relating to the Forum remains the KBA 2020 Report, which documents that manufacturers agreed to adjust calibrations of ECUs for the reduction of Nox.

203. Either as a result of the Forum, dialogue between manufacturers and regulators/government and/or public pressure, the Mercedes Defendants devised software updates that were subject to "voluntary update decisions" ("VUDs") – German national type approval decisions taken by the KBA – that were subsequently found to be unlawful by Constable J in the KBA Judgment at [131] and [134]. All four Mercedes CSVs are the subject of voluntary update decisions. In the case of the other ALGLOs, it appears that there were no purported national TA decisions made in relation to those updates, but neither was there any amendment to TA. The downstream issues that arise in Mercedes will therefore also arise in these cases.

Court decisions

England: The initial Volkswagen Litigation (VW1)

204. The VW1 Litigation was the subject of two relevant substantive judgments prior to its settlement:

    i) The preliminary issues judgment *Crossley 1* which relevantly dealt with, among other matters, Article 3(10) ER issues; and

    ii) The summary judgment/strike out judgment in *Crossley v Volkswagen AG* [2021] EWHC 3444 (QB), 1 All ER (Comm) 107 ("*Crossley 2*"), which considered questions of satisfactory quality.

205. In *Crossley 1*, Waksman J was dealing in the context of Euro 5 with what the Ford Defendants described as "*an open and shut test cycle recognition device*". One type of engine (the EA189 engine) in certain VW vehicles had software that was capable of detecting whether the vehicle was being subjected to an emissions test. When the vehicle was being tested, it would operate in "Mode 1", which was optimised for NOx and other pollutant emissions and test compliance. In all other circumstances the vehicle would operate in "Mode 2", which was optimised for comfort. NOx emissions were significantly higher in Mode 2 than in Mode 1. If it had been running in Mode 2, the VW vehicle would have failed the test.

206. Fairly unsurprisingly Waksman J found that the VW device was a DD. He rejected the Defendants' arguments, amongst others, to the effect that:

    i) The definition of a DD in Article 3(10) of the ER required for the identification of a "reduction of effectiveness" a comparison between the emissions produced in the real world with the relevant software, and the position without the relevant software (i.e., a "*real world vs real world*" comparison) (referred to as the "*True Comparator Argument*"), as opposed to a comparison with the test results ([151(2)]). Waksman J held that where the vehicle could only operate in Mode 1 on the NEDC (with a high EGR rate) but operated only in Mode 2 outside the NEDC (where EGR was always lower) the comparison required was between the functioning of the vehicle in the test and on the road;

    ii) Emissions testing was concerned with the overall reduction in emissions, as opposed to the reduction of any single pollutant, and so if NOx was increased but e.g. HC reduced, it could not be said that there was a reduction in effectiveness of

the ECS (referred to as the "Holistic Argument"): see [151(3)]. Waksman J rejected this at [246]-[267].

207. The case decided no Article 5(2) issues – because it was not suggested that, if the device was a defeat device, it was capable of being justified.

208. In the course of this decision (whose ratio this Court is not bound to follow but will not depart from unless convinced it is wrong) Waksman J held that:

    i) The phrase "*conditions which may reasonably be expected to be encountered in normal vehicle operation and use*" simply applies to the (real-world) situation where the reduction in ECS effectiveness occurs, at [177];

209. "*the question still arises as to what is the proper comparator for the purpose of the reduction. In other words, one has to ask 'reduced in comparison to what?' In my view, the comparison is with what the position was without the offending modulation caused by the change in modes*" [178]. On this basis, the relevant comparison for the purpose of considering reduction in effectiveness is simply between the position with and without the modulation alleged to be a DD. The NEDC test is to be taken as the approximation of or proxy for real-world driving (as a subset of real-world conditions) from the point of view of the Emissions Limits and the conformity of the vehicle thereto. The comparison for the purposes of "reduction of effectiveness" is therefore between the car as calibrated for the "assumed" real-world of the test (the "test or test compliant performance" [182]) and "real" real-world of normal driving conditions: see [194];

    i) The pollutant-by-pollutant (rather than holistic) approach is unsurprising and logical "*since excessive levels of each particular emission are undesirable in themselves*": [248].

210. *Crossley 2* is of considerably less relevance save as to one issue. It dealt with two principal applications: (1) Volkswagen's attempt to strike out or obtain summary judgment against the claimants' deceit claims; and (2) the claimants' application for summary judgment on the issue of satisfactory quality, based in part on an argument as to the invalidity of the CoC. As such the latter issue was close to the "axiomatic breach of contract" argument to be considered below. On the iteration of the argument presented to that court Waksman J rejected as *"clearly unfounded"* the argument that the presence of a defeat device automatically rendered the CoCs invalid. He relied in particular upon conclusions that:

    i) Nothing in the legislation provides that a certificate of conformity automatically becomes void merely because a vehicle is subsequently shown to be non-compliant: [186].

    ii) No authority anywhere in Europe had treated those Volkswagen certificates as automatically invalid [187].

    iii) Acceptance of the claimants' argument would undermine the harmonised EU type-approval scheme [192].

iv) The EU type-approval regime contains detailed mechanisms for addressing non-conformity through recall, remediation, and possible withdrawal of type approval [193].

211. During the course of this judgment these judgments will be referred to on numerous occasions. I do not disagree with either of them.

The CJEU jurisprudence

212. A far more vexed question is the approach which should be taken to the CJEU jurisprudence, of which there is rather more. This is in part because much of the jurisprudence is post Brexit (or in legal terms "post IPCD"). It is also in part because while there are numerous cases, they are built on a fairly narrow base. The Grand Chamber of the CJEU has predominantly considered VW's original "two modes"/switch CRDD and also the thermal and altitude windows subsequently applied by VW. There has been one decision regarding a Mercedes Euro 5 vehicle, and a decision which deals with three unnamed manufacturers' vehicles.

213. As part of that consideration the CJEU has discussed: (i) the DD definition in Article 3(10) ER; (ii) the meaning, scope and proper application of the Article 5(2) Exceptions, (iii) whether a vehicle with a PDD is of satisfactory quality; and (iv) the right to compensation/damages. The questions which arise therefore appear and reappear in a variety of places throughout the judgment. This section offers an overarching introduction to those cases, to which reference back can be made in the context of any particular iteration of the arguments.

214. The CJEU's thinking and conclusions to which reference has been made derive from the following:

i) *CLCV*: a decision of December 2020 (days before IPCD and so the only relevant CJEU decision binding on this Court);

215. Case (C-128/20) ECLI:EU:C:2022:570*GSMB Invest GmbH & Co v Auto Krainer GesmbH* ("*GSMB Invest*");

i) Case (C-134/20) *IR v Volkswagen AG* ("*IR v VW*");

ii) Case (C-145/20) *DS v Porsche Inter Auto GmbH & Co and Volkswagen AG (*"*DS v Porsche*");

iii) Case (C-873/19) *Deutsche Umwelthilfe eV & Co v Volkswagen AG* ("*DUH v VW"*);

iv) Case (C-100/21) EU:C:2023:229 *QB v Mercedes-Benz Group AG* ("*QB v MB"*) concerning a thermal window in a Mercedes Euro 5;

v) Case (C-666/23) EU:C:2025:604 *DS v Volkswagen AG* ("*DS v VW*") following QB and considering a thermal window starting at 12°C.

CLCV: the binding case

216. *CLCV* is the key authority on which reliance is placed. It was decided shortly after *Crossley 1* and days before IPCD. It followed from a request made in criminal proceedings brought in France against a car company. As such the proceedings were anonymised; but the inference from the timings (proceedings having been commenced following press reports in late September 2015) and the facts recited is that it was effectively the same vehicle type as that in focus in *Crossley*.

217. The facts upon which it proceeded were that the unnamed company had put into circulation vehicles equipped with software capable of detecting the approval phase of the vehicles and reducing NOx emissions during the test, with the EGR working to a far lesser extent outside the test – with consequent increase in NOx. The factual basis for the assumed facts was an investigation performed by the French National Investigation Service ("SNE") and further testing by the French Institute for Petroleum and New Energies ("IFPEN") followed by an expert analysis based on those test results. They showed that:

    i) In some of company X's vehicles, NOx emissions were up to 3.6 times higher than the theoretical values recorded when they were approved;

    ii) NOx emissions were specifically reduced when an approval cycle was detected, with the EGR valve open significantly wider;

    iii) There was a device which detected the approval cycle and modified the operation of the exhaust gas recirculation system (the "EGR system") for the purposes of that approval. The existence of that device resulted in an increase in NOx emissions for vehicles driving under normal conditions. The expert also explained that if the operation of the EGR valve in real traffic had been in line with its operation during the TA tests, those vehicles would have produced, especially in urban traffic, significantly (around 50%) less NOx, but probably a little more (around 5% more) carbon monoxide, unburned hydrocarbons and carbon dioxide in return.

218. In line with CJEU process the Court considered four specific questions:

    i) Question 1: The interpretation of the concept of "element of design" in Article 3(10) – did it include a programme operating via the engine control controller?;

    ii) Question 2: The interpretation of the concept of "emission control system" in Article 3(10) – confined to post creation treatment, or also EGR?;

    iii) Question 3: The interpretation of the concept of "defeat device" within Article 3(10) – "*is a device that detects any parameter connected with the conduct of the approval procedures provided for in Regulation No 715/2007, for the purposes of activating or adjusting upwards, during those procedures, the operation of any part of the emission control system, and thus obtaining approval of the vehicle*" a defeat device? And does the fact that it also works outside the test make a difference?;

    iv) Question 4: The interpretation of the exceptions provided for in Article 5 - what is covered, and is slowing down ageing or clogging up within Article 5(2)(a)?

219. As with *Crossley*, the decision of the CJEU that the device was a DD is very unsurprising. The CJEU stated that the definition of a DD in Article 3(10) ER is to be read alongside, and in the light of the wider provisions of the Directive, most obviously both Articles 4 and 5; and is to be read in such a way as to give meaningful effectiveness to the provisions, citing AG Sharpston's Opinion at [106].

220. When read alongside Articles 4(2) and 5(1) in particular, "*it should be observed that that context does not reveal any factors which would allow a distinction to be drawn between the operation of the device at issue during the type approval test phase and during vehicle use under normal conditions*".

    i) Further, citing AG Sharpston's Opinion at [126] with approval, "*the introduction of a mechanism the sole purpose of which is to ensure compliance with the emissions limits laid down by [the ER] only at the type-approval test phase would run counter to the obligation to ensure that emissions are effectively limited under normal conditions of vehicle use*".

    ii) To this end, the Court confirmed that the "*definition of a defeat device confers a broad scope on the concept of 'element of design', which covers both mechanical parts and the electronic components which control the activation of those parts, where they act on the operation of the emission control system and reduce its effectiveness*"; *CLCV*, at [64]; applied later in *GSMB Invest* at [32];

    iii) The context in *CLCV* for the debate about the term "*element of design*" was the dispute about whether software was an *"element of design*". In this case the Claimants say that the point about "*broad scope*" made by the CJEU logically applies to all elements of the Article 3(10) DD definition (such as, say *"reduction in effectiveness"* or what constitutes *"normal vehicle operation and use*"), for the reasons explained at [67] of *CLCV*, namely: teleological interpretation in the light of the goal of the ER, as explained in its Recital 36, which is considerably to reduce NOx emissions in order to improve real world air quality etc.

    iv) It was also found that modulation of EGR rates in an EGR-only vehicle (by changing of EGR valve position) modulates the effectiveness of that ECS: [65] (last sentence), [66] and [93]; and later *GSMB Invest* at [34].

221. The Court also considered the meaning of an "emission control system", RIE and various aspects of Article 5(2)(a) including strict interpretation, "damage", "accident", "need" and alternative technical solutions. It held that:

    i) The concept of an "*emission control system*", within the meaning of Article 3(10) ER covers both: (i) "*exhaust gas aftertreatment*" technologies and strategies that reduce emissions downstream, namely after their formation, and (ii) those "*engine out*" emissions, like the exhaust gas recirculation system, reduce emissions upstream, namely during their formation: *CLCV* at [90], (later applied in *GSMB Invest*, at [33]);

    ii) Devices which "*detect any parameter related to the conduct of the approval procedures*" including the NEDC (or other regulatory test) in order to improve the performance of the ECS during those procedures, and thus obtain TA, constitute a

DD even if such improvement may also occasionally be observed under normal conditions of use: *CLCV*, at [99]-[102];

iii) The exceptions in Article 5(2)(a) (and by extension (b) and (c)) "*must be interpreted strictly"* (in line with consistent and settled CJEU caselaw on principles of construction to the effect that exceptions to general rules must be narrowly read so that general rules are not negated) so that the prohibition on DDs maintains its effectiveness, and so that departure from the ER's clean air objective it safeguards is minimised: see *CLCV* at [111-113]; (later applied in *GSMB Invest*, at [50]);

iv) The phrase "*accident or damage*" in Article 5(2)(a) ER meant "*an unforeseen and sudden occurrence which causes damage or hazards, such as injuries or death*" and "*damage resulting from a violent or sudden cause of action*", such that Article 5(2)(a) enabled the justification of a DD which allows an engine to be protected against sudden and exceptional damage. Thus, clogging and ageing cannot be regarded as an accident or damage, being in principle foreseeable and inherent in the normal operation of the vehicle; and to permit the exception to be so used would render the prohibition on DDs devoid of substance or deprive it of effectiveness: see *CLCV* at [105-110]; [113]. The result is that only "*immediate risks of damage which create a specific hazard when the vehicle is driven are such as to justify the use of a DD*" at [114]. Specifically:

a) The term "accident" refers to an unforeseen and sudden occurrence which causes damage or hazards, such as injuries or death;

b) The term "damage" refers, for its part, to damage generally resulting from a violent or sudden cause of action: *CLCV* at [108].

Other CJEU cases (GSMB Invest et al)

222. *GSMB Invest, IR* and *DS* were decided on the same day by the same panel of judges.

223. *GSMB* concerned another VW EA 189 engine. This one operated only within a temperature window (15/33ºC) and altitude window (less than 1000 metres) which taken together offered a proxy for the NEDC test. Again, as with the *Crossley* vehicle, outside that window the EGR rate reduced down to zero, albeit not in a simple on/off way. However the factual base for the decision is somewhat obscure. The Court proceeded on the basis of quite limited factual findings. These included that the reduction proceeded "*in a linear way down to zero*" [28], and (not entirely consistently) "*the purification of exhaust gas [was] deactivated at an outside temperature of below 15°C and above 33°C*".

224. The arguments raised were apparently not the same as the ones raised here. The only arguments which seem to have been raised by the defendant were (i) that the vehicle in question had been given TA by the KBA, (ii) that the temperature window at issue was widely used, and (iii) that a factual error had been made by the national court.

225. In relation to that device and on those arguments the Court found that:

i) Thermal windows are a "design element" within Article 3(10) ER: The Court confirmed that software which "*detects the air temperature…for the purpose of*

activating, modulating, delaying or deactivating the operation of any part of the emission control system' within the meaning of Article 3(10) of [the Emissions Regulation]" constitutes an "*element of design*" within the meaning of that provision: *GSMB Invest* at [35]. The Claimants here submit that the same logic and analysis must apply to any parameter connected to the engine or aftertreatment system, such as torque, RPM, ambient or charge, MAF, SCR or LNT catalyst temperature, AdBlue average, AdBlue tank fill levels etc. (all of which are in dispute in one form or another in this trial);

ii) Where the thermal window was used to change the operation of the EGR (i.e. reduce the EGR rate) and the effectiveness of the ECS was thereby reduced, that constituted a DD so long as such occurred *"under conditions which may reasonably be expected to be encountered in normal vehicle operation and use"*: see [32]-[37] of *GSMB Invest*;

iii) On the facts of the case: *"Article 3(10) of [the Emissions Regulation], read in conjunction with Article 5(1) of that regulation, must be interpreted as meaning that a device which ensures compliance with the emission limits laid down by that regulation only when the outside temperature is between 15 and 33 °C and the driving altitude is below 1 000 metres constitutes a 'defeat device' within the meaning of Article 3(10) of that regulation.";*

iv) The phrase *"reasonably expected to be encountered in normal vehicle operation and use"* must be given an autonomous EU meaning so that it operates uniformly throughout the EU, taking due account of context: [39]. It meant driving outside the NEDC test in real driving conditions: [40] such as are usually present in the territory of the EU: [43]. That conclusion was supported by the aims of the ER articulated in Article 4(2): [41-43]. The 15-33°C EGR rate thermal window there was found to be a PDD: [46].

226. The CJEU in *GSMB Invest* went on to consider the meaning and scope of the Article 5(2) exceptions and also confirmed its earlier approach to the construction of this provision in *CLCV* with limited addition, confirming that:

i) Emission control devices are distinct from the engine: the Court dismissed the manufacturers' attempts to argue that the concept of protecting the engine includes the EGR Valve, the EGR cooler and the DPF. These are all distinct from the "engine" and cannot found an Article 5(2)(a) justification: [52];

ii) Justification of defeat devices: in answer to the arguments of the German Government, the car dealer, VW (invoking potential sudden losses of vehicle power from valve blockage etc; sudden or unforeseeable losses of power; or the risk of DPF/engine fires) the CJEU emphasised at [61] that the conditions in Article 5(2)(a) are cumulative: there must be justification in both protecting the engine against damage/accident and the need for safe operation;

iii) As a result, the CJEU (at [62] and [70]) confirmed that a thermal window DD "*can be justified under that exception only where it is established that that device strictly meets the need to avoid immediate risks of damage or accident to the engine, caused by a malfunction of a component of the exhaust gas recirculation system, of such a serious nature as to give rise to a specific hazard when a vehicle fitted*

with that device is driven" and in any event "*a defeat device which, under normal driving conditions, operated during most of the year in order to protect the engine from damage or accident and ensure the safe operation of the vehicle could not fall within the exception*".

iv) On the meaning of "need" and how it is to be interpreted: placed in context, Article 5(2)(a) should be read as follows [69]:

> "Article 5(2)(a)…must be interpreted as meaning that a defeat device, which guarantees compliance with the emission limits laid down by that regulation only in the temperature window, cannot fall within the exception to the prohibition on the use of such devices, laid down in that provision, solely because that device contributes to the protection of parts such as the EGR valve, the EGR cooler and the diesel particulate filter, unless it is established that that device strictly meets the need to avoid immediate risks of damage or accident to the engine, caused by a malfunction of one of those parts, of such a serious nature as to give rise to a specific hazard when a vehicle fitted with that device is driven. In any event, a defeat device which, under normal driving conditions, operated during most of the year in order to protect the engine from damage or accident and ensure the safe operation of the vehicle could not fall within the exception provided for in Article 5(2)(a) of Regulation No 715/2007".

v) On technical solutions [69]:

> "in view of the fact that that provision must…be interpreted strictly, it must be held that the 'need' for a defeat device, within the meaning of that provision, exists only where, at the time of the EC type-approval of that device or the vehicle equipped with it, no other technical solution makes it possible to avoid immediate risks of damage or accident to the engine, which give rise to a specific hazard when driving the vehicle" (the "best available technology requirement").

227. *GSMB Invest* was subsequently considered in more detail in *DUH v VW*, another case concerning the VW EA 189 engine. In that case the Court was considering the update applied to "fix" the two driving modes as per *Crossley*. That fix reduced the EGR rate from 100% at 15°C, to 85% between -9°C and 11°C, and zero below -9°C. The Court in *DUH* found:

i) First, at [92] Recital 7 of the ER identifies that when the EU legislature determined Emissions Limits for pollutants, it took into account "*the economic interests of manufacturers and, in particular, the costs imposed on undertakings by the need to comply with those limits*". As a result, "*it is thus for manufacturers to adapt and apply technical devices capable of complying with those limits as that regulation does not require the use of any particular technology*" (applying *GSMB Invest* at [67]);

ii) Second, at [93], the objective of the ER, consisting of guaranteeing a high level of protection of the environment and improving air quality, means NOx emissions being limited throughout the normal life of vehicles. As a result, "*permitting a defeat device under Article 5(2)(a) of that regulation solely because, for example,*

research costs are high, the technical device is expensive or vehicle maintenance is more frequent or more costly for the user would jeopardise that aim";

iii) Third, at [94], "need" "*exists only where, at the time of the EC type-approval of that device or of the vehicle equipped with it, no other technical solution makes it possible to avoid immediate risks of damage or accident to the engine, which give rise to a specific hazard when driving the vehicle*";

iv) Fourth, even a partial reduction in EGR rate (in that case a 15% reduction between 11°C and -9°C, pursuant to VW's thermal window "fix" for its original CRDD), was a DD: [84]-[85]. There is no *de minimis* rule for DDs.

228. The findings in *GSMB Invest* were also followed in *QB v MB* (see [58] to [66]). *QB v MB* concerned a thermal window in a Mercedes Euro 5 (start at a temperature above 0°C, although the precise starting point for derating and ramping rate were disputed). The Court considered the obligation on Member States to provide a right to compensation to individual purchasers, and opined that the fact that the vehicle had TA was not determinative. The Court in *QB* also considered the question of whether EU law requires that a purchaser of a vehicle has a civil claim for damages against the vehicle manufacturer on the basis of tortious liability in the event of any culpable (negligent or intentional) act on the part of the vehicle manufacturer in relation to the placing on the market of a vehicle equipped with a prohibited defeat device, concluding that it did. That decision was then followed in *CM*. Those decisions are relied upon by the Claimants in relation to the actionability arguments.

229. *DS v VW* followed *QB* while considering a thermal window starting at 12°C. It also considered German law on quantification of compensation; finding that the prohibition on DDs and right to compensation arise in relation to DDs installed by updates as well as those installed at the date of acquisition; and finding that as Article 5(2) ER lays down the exceptions to the prohibition, the German exception to a right to compensation in cases of unavoidable error cannot be applied to further cut back the right to compensation, including where the error resulted from TA having been granted.

Other national decisions

230. The cases are primarily German and Austrian and include decisions from the Bundesgerichtshof ("BGH") / Federal Court of Justice ("OGH") respectively, the highest civil courts in each jurisdiction.

231. *Deutsche Umwelthilfe e.V. v Bundesrepublik Deutschland and joined party Volkswagen AG* 20 February 2023 is the leading German decision on the application of the CJEU's thermal windows principles to the facts of a case. Following the CJEU's decision in *DUH*, the Administrative Court of Schleswig-Holstein found that VW's thermal window update after the VW1 CRDD (DM) removal approved by the KBA was also a PDD.

232. On 17 January 2024, that court (in case number D3 A 332/20) handed down a further decision relating to the "fix" in VW EA189 engines. The court made the following relevant findings:

i) Reduction in effectiveness: the court can consider either: (i) the process of emission control; or (ii) its result when assessing reduction in effectiveness ([476]). The

reduction of effectiveness in one part of the ECS can be compensated for by another so that there is no reduction in the overall effect of the ECS (as regards NOx emissions) ([453]). A DD exists if software of the ECU influences the ECS so that full effectiveness is "*only guaranteed under conditions that correspond to those of the test procedure and is reduced in its effectiveness outside these conditions (mere remodelling of the test conditions)*" ([461]), citing *CLCV* at [462]. Any reduction in effectiveness is covered; "*the degree of change is therefore irrelevant*", and it is a relative question so there is no requirement for a reduction compared to an absolute value [§477]. There was a reduction in effectiveness in this case due to the operation of the software on the EGR valve: the fact of any increase in raw emissions of NOx "is the only important factor" ([501-504]);

ii) Article 5(2)(a) exceptions: Applying *CLCV*, *GSMB Invest*, *Volkswagen* and *DS*, the exception must be interpreted strictly (§517), and "engine" must not be interpreted broadly ([521-525]). Manufacturers must do everything possible to reduce emissions before claiming an exception under Article 5(2) ER, as negatively impacting environmental protection and health should be a *"last resort"* ([550]), with a truly "*necessary*" device ([542-545]);

iii) PDDs generally: The thermal window switchover logic ([565]), the altitude and air pressure devices ([643]) and the idling time and taxi circuit devices, were all PDDs ([650]). The requirement in Article 3(10) that the element of design senses a parameter "*for the purpose of*" acting on the ECS that reduces the effectiveness is not a subjective test [658].

233. The BGH made observations, in a further decision issued on 26 June 2023 concerning a VW Passat with an EA 288 Euro 6 engine equipped with a thermal window and driving-curve detection system:

i) Definition of a DD and reduction in effectiveness: [50]: a DD may be present if a part of the ECS alters its function based on certain parameters and reduces ECS effectiveness under NDC. It is not about compliance with emissions limits under NEDC testing, but whether ECS effectiveness remains unchanged in normal use as compared to the set up in the NEDC test;

ii) On burden of proof: [52]-[53]: The claimant must provide the factual basis that a DD exists, but the requirements on the claimant "must not be overstretched", and the burden of proof for the permissibility of a DD is normally on the Defendant;

iii) Normal driving conditions: [49]: must be assessed across conditions "*usual throughout the territory of the Union*" as a result of the "*territorial scope of the Regulation*".

234. In Austria the OGH has decided a large number of cases regarding DDs. Their key decisions were on 27 June 2023 (case numbers 1 Ob 149/22a and 6 Ob 150/22k), and concerned VW vehicles which contained CRDD(DM)s and were then fixed with thermal windows:

i) Burden of proof: In 1 Ob 149/22a the Court found that the burden of proof lies with the defendant to demonstrate that a device falls within Article 5(2)(a) (at [46]) and, if the burden is not discharged, then the Court will presume that a PDD is present;

ii) Thermal Windows and the best available technology requirement: In 6 Ob 150/22k the Court cited the CJEU case law and held that a device cannot fall within Article 5(2)(a) if it operates for most of the year ([25]). Further, citing *DUH*, the court considered that a necessary condition under Article 5(2)(a) to be that "*no other technical solution can avert immediate risks to the engine in the form of damage or accident which, when driving a vehicle, pose a specific danger*" ([p.24]). A similar decision was made in 3 Ob 121/23z where it was found that a Thermal Window was a PDD because it was active in Austria for most of the year (at [14]) and, on that basis, any engine protection requirements were irrelevant (at [15]). It was further confirmed that, in light of *GSMB Invest*, "*what matters are the conditions…everywhere within the borders of the EU*" when assessing whether a device is a DD ([14]).

235. Finally in opening the Claimants placed a great deal of emphasis on a decision of the court of Schleswig Holstein of 23 May 2023 (3 A 3/20) which concerns SCR dual dosing. The Claimants submitted that this was a lengthy, extremely carefully reasoned decision, dealing with a lot of the relevant science. The main finding in that case (which concerned Vauxhall engines) was that if the software of an engine control system is designed in such a way that, irrespective of whether a vehicle is currently on the test bench or in real road traffic, it influences the emission control system in such a way that its full effectiveness is only guaranteed under conditions which correspond to those of the test procedure (here: NEDC) and is reduced in its effectiveness outside these conditions (e.g. replicating the test conditions), there is a defeat device. There was also a finding (echoing *GSMB Invest*) that the conditions that can reasonably be expected during normal vehicle operation include ambient temperatures between -15 °C and +40 °C. The court therefore found that engine management software that reduces the effectiveness of an exhaust gas recirculation system and/or SCR catalyst as part of the exhaust aftertreatment system (thermal window) under these conditions is a defeat device.

236. It was pointed out by Mercedes that this decision is not only (on any analysis) not binding on this court, but also that as a decision of a foreign court on the merits between different claimants and different defendants, it was not even admissible. In closing mention of the May Schleswig Holstein judgment was conspicuous by its almost entire absence.

237. For the record I should just note that having read that decision, I conclude that although dealing with technical detail far more completely than most of the other decisions cited, it is entirely predicated on the decisions of the CJEU, including those which are not binding on this Court. It is not therefore as revelatory or as useful as was suggested in opening; indeed to the extent it was admissible at all, it adds nothing material.

238. There was rather more emphasis placed in closing on two other decisions of the court of Schleswig Holstein – February and November 2023.

i) Higher Administrative Court (OVG) Schleswig-Holstein decision of 20 February 2023 A113/18;

ii) Higher Administrative Court (OVG) Schleswig-Holstein decision of 25 November 2025 4 LB 36/23.

239. Other national authorities relied upon were:

i) Higher Administrative Court (OVG) Schleswig-Holstein decision of 23 May 2023 A/320;

ii) Stichting Car Claim v Stellantis [C/13/712812 / HA ZA 22-72]CT;

iii) Regional Court (LG) Ravensburg Decision of 12 February 2021, 2 O 393/20;

iv) Higher Regional Court (OLG) Celle Judgment of 20 March 2024, 7 U 287/22;

v) Higher Regional Court (OLG) Celle Judgment of 19 June 2024, 7 U 149/22;

vi) Higher Regional Court (OLG) Karlsruhe Judgment of 24 January 2024, 6 U 10/21;

vii) Higher Regional Court (OLG) Stuttgart Judgment of 19 October 2023, 24 U 103/22;

viii) Higher Regional Court (OLG) Stuttgart Judgment of 9 November 2023, 24 U 14/21;

ix) Higher Regional Court (OLG) Stuttgart Judgment of 11 January 2024, 24 U 241/22;

x) Higher Regional Court (OLG) Stuttgart Judgment of 22 February 2024, 24 U 254/21;

xi) Higher Regional Court (OLG) Karlsruhe Judgment of 25 September 2024, 6 U 155/21;

xii) Higher Regional Court (OLG) Karlsruhe Judgment of 13 December 2023, 6 U 198/20;

xiii) Higher Regional Court (OLG) Stuttgart Judgment of 29 February 2024, 24 U 1424/22;

xiv) Higher Regional Court (OLG) Karlsruhe Judgment of 26 June 2024, 6 U 215/21;

xv) Higher Administrative Court (OVG) Schleswig-Holstein Decision of 6 November 2019, 5 MB 3/19.

<u>The admissible legal background: conclusions</u>

240. There was much discussion and citation of authority as to the relevance and bindingness of the authorities which had been cited.

241. By closing the central issues, and the only ones which require to be determined in the main body of the judgment, are:

i) The question of what elements of *CLCV* are binding;

ii) The question of the extent to which post IPCD authority (which would if pre-IPCD be binding) should be regarded as persuasive and should not be departed from unless there is compelling reason to do so;

iii) The question(s) of what the post IPCD authorities do decide if they are regarded as persuasive.

CLCV: conclusions

242. So far as *CLCV* is concerned, I reach the following conclusions.

243. So far as Article 3(10) is concerned *CLCV* provides no binding authority for what constitutes a defeat device at large. As explained above, that was not a question which was referred to the CJEU. On the facts (obvious CRDD) that is hardly surprising.

244. The question on defeat devices which was referred ([44]) and answered ([116]) was narrow and specific:

> "[Q]: Is a device that detects any parameter connected with the conduct of the approval procedures provided for in Regulation No 715/2007, for the purposes of activating or adjusting upwards, during those procedures, the operation of any part of the emission control system, and thus obtaining approval of the vehicle a defeat device?
>
> [A]: …a device which detects any parameter related to the conduct of the approval procedures provided for by that regulation in order to improve the performance of the emission control system during those procedures, and thus obtain approval of the vehicle, constitutes a 'defeat device', within the meaning of that provision, even if such an improvement may also be observed, occasionally, under normal conditions of vehicle use".

245. The conclusion of the CJEU therefore does not provide an answer to whether Article 3(10) is confined to CRDDs, or CRDDs plus "boundary devices" or is to be interpreted as the Claimants contend. While it plainly rejects the argument that test compliance is all that needs to be achieved, it is consistent with a pure CRDD approach. Embedded in both question and answer are the elements of (i) differential operation and (ii) purpose being to pass the test.

246. *CLCV* therefore does not in any sense drive a conclusion that the Claimants' approach is to be preferred.

247. On construction and *CLCV* the key proposition on which the Claimants relied was that *CLCV* establishes that the notion of a "defeat device" is to be read broadly, since a broad approach was taken to each of the elements actually considered and its purpose in essence is to prevent the goals of the ER, namely reduced real-world NOx emissions from passenger vehicles, being subverted.

248. I do not accept this submission that the broad approach taken to the individual elements of the questions which the Court did consider themselves drive a conclusion that the overall interpretation of Article 3(10) must be very broad. Nor do I accept that *CLCV* per se sets the framework about how Article 3(10) is to be construed.

249. However I do accept that *CLCV* establishes that:

i) It is not an answer to say that the "test mode" triggers from time to time in real life. [There remains an issue as to the frequency with which that must occur and whether

the operation should be regarded as part and parcel of real life or an occurrence "by chance";

ii) When it comes to the question of the interpretation of Article 3(10) the interpretative approach prescribed by EU Law principles will have to be used: language + context + purpose. The question of the correct conclusions as to those elements of the ER will be reverted to below, and are not *CLCV* dependent.

250. As to Article 5(2) however it is fair to say that *CLCV* at least begins to set the framework for construction. As a result of *CLCV* I am bound by findings/conclusions that:

i) The exceptions under Article 5(2)(a) (and by extension (b) and (c)) must be interpreted strictly consistently with EU Law principles and to safeguard the effectiveness of the defeat device provisions;

ii) Exceptions cannot be implied;

iii) Article 5(2)(a) does not cover a defeat device that protects an engine against foreseeable events (such as clogging up and ageing of the engine) inherent to the normal operation of the vehicle.

Status of post IPCD authority: Farley

251. The Claimants contend that even though there is limited truly binding material the post IPCD authority (which would if pre-IPCD be binding) should be regarded as persuasive and should not be departed from unless there is truly compelling reason to do so. To do otherwise, the Claimants say:

> "turns mainland Great Britain into an isolated 'defeat device Brexit Island' – a singular territory where the approach to PDDs is significantly more relaxed (in favour of permitting extensive modulation of an ECS) than in Northern Ireland, the EU, the US, Australia, South Korea, Israel, or any territory working under the UNECE approach that mirrors the EU approach."

252. That is an argument which rests primarily on the case of *Farley v Paymaster (1836)* [2025] EWCA Civ 1117 ("*Farley*") which the Claimants say determines the approach to post IPCD CJEU law (at least pending the decision of the Supreme Court).

253. *Farley* concerned the interpretation and application of the GDPR, and specifically, whether the Judge below had erred in law by striking out the data protection claims: [23]. The Respondent contended that distress was an essential ingredient of a data protection claim, that there was a *de minimis* threshold of seriousness for data protection claims, and that the claims were not sufficiently serious. The Appellants relied on a line of post-IPCD CJEU authority which ran counter to that contention: at [60]. The Respondent, citing *Tower Bridge GP Ltd v Revenue and Customs Commissioners* [2022] STC 1324, argued that the English Court was not required to follow the post-IPCD CJEU decisions "*which appear to be flawed or inconsistent*": [61].

254. The Claimants say that *Farley* sets a test whereby compelling or weighty reasons need to be identified before a court can properly depart from post IPCD CJEU decisions. They reach this position by noting that in *Farley*, the Court of Appeal accepted that it was not bound by the post-IPCD CJEU case law; but it rejected the Respondent's invitation to

depart from the course taken by the CJEU. In doing so the Court noted that departing from post-IPCD CJEU jurisprudence "*is open to the UK as a political choice and a legislative option*": [67]. However, it concluded that in that case a judicial decision to depart from a course set by the CJEU in relation to the same legislation "*would call for sufficiently compelling legal reasons*": [67].

255. Hence in *Farley*, the Court noted that the GDPR had direct effect in the UK at the material time (i.e. when the claims accrued), and that Parliament had chosen to use identical language in the UK iteration of the GDPR (as assimilated domestically); it held that *"[s]elf-evidently*", it was damaging to legal certainty to allow "*divergent interpretations of the same legislative text*"; and on this basis and *"all things being equal"*, it made "*good legal sense for the court to interpret and apply the GDPR in conformity with settled CJEU jurisprudence*": all at [67]. The post-IPCD CJEU reasoning given in the case was "*logical and sufficient"* and was not "*fundamentally flawed"*, and this was the case even though the CJEU there disagreed with the position of the Advocate-General: [71]. It was therefore found that the post-IPCD CJEU decisions provided "*a touchstone by which most if not all of the remaining issues in this case can be fairly resolved*": [75]. There was no *"sufficiently weighty reason"* to depart from settled CJEU case law: [76].

256. The Claimants contend that the Court of Appeal therefore articulated and applied a test of "*sufficiently compelling legal reasons"* which is generally applicable. The Claimants contend that this is reflective of the fact that the basic predicate of EUWA (as articulated in the majority reasoning in *Lipton*) is plainly legal continuity, to minimise the uncertainty that may flow from exiting the EU; to that end, the discretion conferred by s 6 EUWA is to be exercised in line with that animating aim. It equally follows, the Claimants say, from the fact that the legislative powers granted under s 8 EUWA are limited in substance to those necessary to deal with "deficiencies" (i.e. incoherences) that would arise if the provision were left unaltered. They submit that the ongoing international and cross border nature of the emissions regime – perhaps with particular reference to the Northern Ireland position, but also by reference to UNECE obligations and post-Brexit regulatory co-operation (inter alia by reference to the "GB facsimiles" of the Market Surveillance Regulation, the ER and the New IR) add force to the submission that this is the right approach.

257. For the Defendants it is submitted that the Claimants place excessive weight on a single phrase from *Farley* and that to pursue the Claimants' analysis risks treating post IPCD CJEU authority as effectively binding, which is contrary to the statutory scheme of EUWA.

258. That submission is in my view substantially well founded. Careful thought was, of course, given to the wording of the statute. A regime emerged and was encapsulated in s. 4 EUWA. It provided thus:

> "(1) A court or tribunal (a) is not bound by any principles laid down, or any decisions made, on or after [IPCD] by the European Court, ….
>
> (2) Subject to this and subsections (3) to (6), a court or tribunal may have regard to anything done on or after [IPCD] by the European Court, another EU entity or the EU so far as it is relevant to any matter before the court or tribunal."

259. The primary position is clearly and unequivocally stated: *"not binding*". It is qualified only by a "*may*" wording. That "*may*" wording confers a discretion. That discretion is not confined or defined by a requirement for compelling or weighty reasons. I do not accept that the Court in *Farley* was purporting to establish any general approach of principle as to how to address this discretion. It was not asked to produce any gloss on the words of the statute; and nor did it purport to do so. Read overall, what the Court was doing was making a decision on the facts, against a backdrop where it considered the post IPCD GDPR case law to be correct on its merits. Note in particular may be taken here of (i) [38(3)] of the judgment where Warby LJ describes the reasoning of a post IPCD decision (on an earlier point) as "*persuasive and consistent with*" pre-IPCD authority, (ii) the robustness with which he dismissed the argument that English law to date conflicted with the post IPCD line of authority (see [62] and the paragraphs following, dismissing the cases relied on as "*obiter and not in point*", not even arguably binding, pre-CJEU and of no assistance on the facts) and; (iii) at [71] the assessment of the logic of the relevant CJEU case law.

260. At the same time however I do consider that *Farley* gives a useful indication as to the kinds of factors which will at least sometimes come into the equation in the exercise of the discretion given by 6(2). Points highlighted by Warby LJ as tending to give real pause before departing from post-IPCD authority include (i) whether the regulation in question is one which had direct effect in this jurisdiction; (ii) whether post-Brexit the same wording has been used for the domestic successor legislation.

261. Accordingly, so far as the approach to the authorities is concerned, I proceed below on the following basis:

    i) Pre-IPCD authority is binding – on the issues which it can properly be regarded as determining;

    ii) Where post-IPCD authority follows or is logically predicated on binding pre-IPCD authority it will almost always be appropriate to follow that authority on the point or points in relation to which it follows or is logically predicated on the earlier authority. This is an approach which is consistent with that taken in *Warner Music UK Ltd v TuneIn Inc* [2021] EWCA Civ 441, and *Eversfield Preparatory School Trust Ltd v Diverse World Ltd* [2025] EWCC 33;

    iii) Absent such an underpinning of pre-IPCD authority, post-IPCD authority is not binding, but is something which may be taken into account, if in all the circumstances of the case the court considers it appropriate to do so;

    iv) Factors such as those in *Farley* are the kinds of factors which may well be brought into the equation in weighing whether in all the circumstances of the case post-IPCD authority is to be followed or departed from;

    v) So too are discernible errors in the post-IPCD authorities: see *Umbrella Interchange Fee Claimants v Umbrella Interchange Fee Defendants* [2024] EWCA Civ 1559 and *Tower Bridge GP Ltd v Revenue and Customs Commissioners* [2022] EWCA Civ 998.

262. I will come below to the extent to which the relevant post-IPCD cases are logically predicated on pre-IPCD authority or simply follow it and the extent to which errors can

be discerned in those cases. First however it is apposite to note that the Claimants are correct that in this case there are aspects of the regulatory history which point towards a degree of careful consideration being appropriate before departing from post-IPCD authority in this area. These are:

i) The fact that the regime is essentially one adopted from the pre-IPCD EU Regulations and that the court is considering the wording of EU Regulations which continue to apply in the EU post-IPCD. Notably in the KBA trial Mercedes submitted that during the transition period immediately following the IP completion day, i.e. from 1 January 2021 to 31 December 2022, the UK would be obliged to follow mandatory recall decisions with it being submitted that Parliament intended that after Brexit the UK should be, *"a decision-taker under the regime, even though it could not be a decision-maker"*.

ii) The fact that the system of type approval has been carried over into the UK in such a way that GB type approval can be based on EU Type Approval Authority documentation or on a UN Type approval (which is based on identical wording so far as concerns the provisions in focus in this case).

263. It follows that while I do not accept the Claimants' *"sufficiently compelling reason"* approach as a generalised test and the decision whether or not to depart from post-IPCD authority is one for the applicable court's discretion, I do consider that in this case the history of the regulatory background, its nature and the implications for certainty suggest that departure from post-IPCD authority will require some countervailing reasons.

Post IPCD-authority: conclusions

GSMB Invest

264. The main battleground here related to the decision in *GSMB Invest* which was a fulcrum on which subsequent authority turned, as can be seen from the discussion above. The Defendants mounted a very robust attack on *GSMB Invest*, despite its status as a nine judge (hence denoted as a case of heightened complexity and importance) Full Court decision. Those criticisms, in barest summary, included contentions that:

i) The decision was based on a false premise that the emissions limits applied outside the NEDC test;

ii) The decision was decided on the basis of a distorted and incomplete factual record including concessions now known to be false and wrong factual findings by the national court;

iii) The decision was internally incoherent, with Ford arguing that *GSMB Invest* is a judgment in which "*removal of a single brick causes the entire edifice to fall*". This is not a matter of evaluative disagreement but a failure of legal logic;

iv) *GSMB Invest* renders the qualifying language of Article 3(10) nugatory;

v) It leads to absurd and unworkable consequences: necessary calibrations for combustion stability, hardware protection, soot control and oil dilution become presumptively illegal. The inevitable consequence is a hypothetical "dream car"

capable of maintaining peak NOx control in all reasonably encountered conditions without compromise.

265. Having spent a good deal of time with the submissions on both sides and the *GSMB Invest* AG opinion and decision, I conclude that there is considerable force in those submissions, such that even if the Claimants' test of compelling or weighty reasons were applicable, it would not be contrary to principle to depart from *GSMB Invest.*

266. The reasons why that conclusion has been reached are as follows.

267. The analysis involved in the questions before this Court and the Courts in *GSMB Invest* and similar cases is complex and multifaceted. The view that one takes on one point can have a knock on effect on the approach to another. It therefore cannot be assumed that inaccuracies can be ringfenced.

268. In *GSMB Invest* the nature of the exercise was one where the CJEU (i) considered just one engine type of one manufacturer (it will be recalled that it was decided solely in relation to the Volkswagen thermal window) and (ii) had a very limited factual evidence base involving findings, assumptions and concessions.

269. It is indubitably the case that the Court in *GSMB Invest*, like all courts considering issues on this topic before this case, had a vastly less developed and detailed evidence base on which to operate. *GSMB Invest* was a joined series of references all of which were at a relatively preliminary stage of the case (though for different reasons). The Court in *GSMB Invest* lacked the benefit of the weeks of evidence on multiple OEM architectures, multiple slightly different iterations of similar alleged defeat devices, focussed testing, trade-offs between pollutants, safety risks, and calibration practice across the industry which has formed part of the evidential matrix in this case. Nor indeed did it have the exhaustive and excellent expert evidence on "*normal driving conditions*" and the difficulties involved in that concept.

270. The simple fact of that gulf in evidential detail – and nuance – might not in and of itself be enough to persuade this Court to take its own course. However during the course of submissions the Defendants have made good a number of points where it appears that the Court in *GSMB Invest* was operating on the basis of false concessions, or misapprehensions, or misunderstandings.

271. Perhaps the most important of these was one which was based on the finding of the referring court. At [23] of the decision the Court noted that "*That court adds that Article 3(9) of Regulation No 692/2008 determines the period of time in which efficient operation of the engine must be achieved after a cold start. Under that provision, the NOx aftertreatment device must reach a sufficiently high temperature for efficient operation within 400 seconds after a cold start at -7°C.*" In other words the referring Court told the CJEU that diesel compression engines were required to pass the cold start type 6 test at minus 7°C.

272. It is plain to see how such a statement might well feed into a conclusion that "*The latter provision confirms the interpretation that the emission limits laid down by Regulation No 715/2007 must be complied with when temperatures are significantly lower than 15 °C.*" ([45] of *GSMB Invest*); and hence to an approach to temperature windows at [46] *"software such as that at issue in the main proceedings reduces the effectiveness of the*

emission control system 'under conditions which may reasonably be expected to be encountered in normal vehicle operation and use', within the meaning of Article 3(10) of Regulation No 715/2007, and therefore constitutes a defeat device within the meaning of that provision."

273. However that statement (adopted by the *GSMB* Court at [45]) is, simply, wrong. As Ms Howard KC pointed out (reflecting a dedicated forensic exercise on her part which this judgment cannot fully capture):

> "that type 6 test relates to carbon monoxide and hydrocarbon exhaust limits, not NOx, and the diesel compression engines do not have to comply with it.... by virtue of Article 3.9 or Regulation 692 diesel engines do not have to comply with that test[4]. All they have to do is to provide information to the type approval authority about the temperature of the after-treatment catalyst.... that first paragraph of Article 3.9, relates to the LNT or the SCR catalyst. It does not relate to the EGR ... EGR is dealt with separately in the second paragraph. There is a separate obligation to provide information about the operation of the EGR system and how it functions at low temperatures and what its effect on emissions is[5]."

274. In one respect therefore it is clear that the *GSMB Invest* decision proceeded on the basis of an error fed to it by the referring court. What is more is that error is not insignificant, because when one looks at the emissions levels actually prescribed for the engines to which the test did apply (i.e. petrol engines) one finds that the level of emissions permitted under the low temperature test was 15 to 18 times more than those applicable at high ambient temperatures. Therefore the error points towards an approach which is very much in tension with the clear approach in relation to petrol engines.

275. The second respect in which the *GSMB Invest* decision demonstrably lacks a robust foundation is that the arguments on NDC were simplified and short circuited by a concession that "*it is common ground that ambient temperatures below 15 °C and driving on roads at an altitude above 1 000 metres are to be considered as normal within the territory of the European Union"*. That is not common ground here. Indeed this case has both a vibrant debate about the meaning of "*normal driving conditions*" in terms of whether they are to be pegged to usual, or simply regularly encountered and also extensive, highly valuable expert evidence as to what conditions are encountered with what frequency and by reference to driving patterns.

276. The third specific problem with *GSMB Invest* is the way that it proceeds from a finding in *CLCV* [96] and [101] that the EGR system should be in operation both in test and "*under normal conditions of vehicle use*" to an approach not consistent with *CLCV* (or the agreed position before me) that emission limits do not operate outside the TA test conditions.

277. It follows that regardless of the conclusion on *Farley* I do not consider that *GSMB Invest* should be treated as binding or persuasive in relation to thermal windows. This does not

[4] Article 3(9) says in terms: "The Type 6 test measuring emissions at low temperatures set out in Annex VIII shall not apply to diesel vehicles."

[5] Further on in Article 3(9): "the manufacturer shall provide the approval authority with information on the operating strategy of the exhaust gas recirculation system (EGR), including its functioning at low temperatures."

mean that a thermal window case may not be right, but if it is right, it must be justified on the basis of the arguments before me, and not by reference to *GSMB Invest*. Since *GSMB* is the fulcrum case in the EU jurisprudence post IPCD, it follows that a similar approach can be adopted with *QB* and *CM* as regards points which follow from *GSMB*. Where they deal with tortious actionability they need to be considered separately, and that is best done in the context of those arguments later in the judgment.

Procedural Background

278. Each of the Claimants in the NOx Group Litigation purchased, leased or otherwise acquired a diesel vehicle, which was manufactured and/or supplied by one of the Defendants. Each of the Claimants has commenced proceedings in the High Court in relation to that purchase.

Pan NOx Litigation

279. The Court issued the first Claim Form in the Mercedes litigation on 8 May 2020. This was followed by the first Claim Forms in the Nissan / Renault (2 June 2021), PCD (11 June 2021) and Ford (9 July 2021) cases. On 17 May 2023, Senior Master Fontaine made the GLO in the Mercedes litigation.

280. On 19 July 2023, Fraser J (as he then was) gave directions in the Mercedes GLO, including for a CMC in March 2024 and (provisionally) that there be trials in October 2024, February 2025 and October 2025. At that time, the non-Mercedes Claimants were preparing to issue applications for GLOs in their respective proceedings. They included the Claimants in the other NOx cases: (i) Opel/Vauxhall; (ii) VW; (iii) JLR; (iv) BMW; (v) FCA/Suzuki; (vi) Volvo; (vii) Hyundai-Kia; (viii) Toyota; and (ix) Mazda.

281. In the light of the proceedings which then commenced to be issued, on 16 November 2023 the President of the King's Bench Division wrote to the parties expressing concerns about the potential costs and the potential burden on court resources. A further hearing was convened on 8 December 2023 at which the President, sitting with the Managing Judges and Senior Master Cook directed that the claims against each OEM be case managed together, as "Pan NOx" proceedings, with Mercedes as a Lead GLO. The Court gave directions, *inter alia*, for the selection of ALGLOs, for the attendance of other manufacturers at the "Second Progress CMC" in the MB GLO in January 2024, and for converting the March 2024 CMC into a 5-day Pan-NOx case management hearing to set down detailed directions to make use of the trial windows.

282. That decision, taken in part with an eye to Court resources, but also very much with an eye to obtaining rulings which might be of service across the entire range of NOx litigation, has proved its wisdom. One point which was made at the time was that similar alleged defeat devices might prove to have been calibrated or to work in some respects differently (either by itself or in co-operation with another facet of the engine), with the result that what was a defeat device in one vehicle was, in a subtly different iteration, not a defeat device in another vehicle. As this judgment will show, that is exactly what has happened.

283. At that January hearing Ford volunteered to be an ALGLO and was pencilled in as a Lead GLO with the question of other GLOs left to be considered in another hearing in March.

At the March 2024 CMC the ALGLOs were selected/confirmed (including Nissan/Renault and PCD).

284. The overall structure of the litigation was ordered in three initial tranches:

    i) A KBA Trial in October 2024 to consider solely issues relating to the binding nature of KBA Decisions;

    ii) A PDD Trial beginning in October 2025, with a 10 week window for evidence followed by a 3 week (plus reading) window for closing and legal submissions at which hearing Non-ALGLO Defendants would be invited to make non-duplicative representations on issues of law; and

    iii) A Quantum Trial beginning in October 2026.

285. Directions were also made for sample vehicles, statements of case and disclosure, the testing programme, and expert evidence. Initially, it was directed that there were to be 52 sample vehicles in total, namely 16 Mercedes sample vehicles drawn from vehicles with engine categories OM651, OM642 and OM607; 12 Ford sample vehicles; 12 PCD sample vehicles; 6 Nissan sample vehicles; and 6 Renault sample vehicles. Provision was made for later consideration as to whether there should be any reduction or refinement of the number of sample vehicles to be considered at the PDD Trial.

286. Paragraphs 32 and Schedule 1 to the Order set out the factual and legal issues for determination at the PDD trial. It was the first of a series of Pan NOx hearings to case manage these proceedings to the PDD trial.

287. The March 2024 Order further provided that any judgments following the KBA Trial or the PDD Trial would bind all parties in the Pan NOx litigation, including the Non-ALGLOs, on issues of law, regardless of whether any such party had participated in the trials.

288. A Pan-Lead CRO was subsequently agreed. Since each GLO is separate, the Pan-Lead CRO includes a selection notice process requiring the Claimants to provide notice of the potential collateral use of documents disclosed by one Lead Defendant against another.

289. From March 2024 it was quite clear that expert evidence and testing would be at the heart of the case.

290. Permission was given for each party to rely on expert evidence in automotive software engineering and mechanical engineering. A timetable was set for experts' discussions, joint statements and the exchange of reports (although the notes record that extensions occurred in practice);

    i) The parties were directed to meet and seek to agree a testing programme, including how software updates would be applied and removed;

    ii) The timetable was set to permit supplemental reports to be exchanged well ahead of August 2025.

291. By June 2024 the sample vehicle regime initially envisaged 52 sample vehicles in total. The number was later reduced.

292. In autumn as a regime hung in the balance a further issue emerged. The Claimants proposed unilateral testing and the Lead Defendants objected. Progress meetings took place on 20 September, 27 September and 4 October 2024. The Claimants ultimately confirmed that they would not proceed with unilateral testing, following an indication from the court.

293. In October 2024 the KBA trial took place before Constable J. Judgment was handed down on 14 November: [2024] EWHC 2904 (KB).

294. Late autumn of 2024 was all about two things: testing and the pressure to get Individual Particulars of Claim ("IPOCs") served before Christmas. At the October CMC some of the Defendants had been sceptical about the value of postIPOC testing. On 18 November 2024 the First Testing Order (made following an October 2024 CMC) directed inspection of the sample vehicles and PreIPOC testing (NEDC/WLTP). Pre-IPOC Testing involved the sample vehicles being inspected on behalf of the relevant Lead Defendant and Claimants and baseline tests being conducted to establish the condition and performance of the sample vehicles. This was originally pencilled in for just ahead of service of IPOCs in December 2024.

295. The November Order also provided for discussions concerning a PostIPOC testing programme which was envisaged to cover how the CSVs operate (in accordance with IPOCs or not) and potentially (but doubted by some) whether the vehicles contained defeat devices and whether reduction in effectiveness was apparent.

296. IPOCs were due on 13 December 2024. That did not occur. For example:

    i) Mercedes IPOCs were filed between 16 December 2024 and 14 January 2025, and amendments to three Mercedes IPOCs were later deemed served on 12 February 2025.

    ii) Renault IPOCs were served on 13 December 2024 and were supplemented by an addendum (including torque cutoff allegations) served on 30 January 2025.

297. Pre-IPOC testing then started (behind schedule) in February 2025. At the March 2025 CMC the sample vehicles were reduced to 20 Core Sample Vehicles (CSVs), namely 4 Mercedes, 6 Ford, 4 PCD, 3 Renault and 3 Nissan. Post-IPOC testing proposals had been put forward around the turn of the year and were considered, with considerable issues as to the range of tests needed including as to whether on road testing would be useful and if so, what it should consist of and further short hearings followed in order to seek agreement.

298. On 11 April 2025 the Second Testing Order was agreed. It set principal directions for Post-IPOC testing, including chassis dynamometer testing and on road PEMS testing, at independent testing houses and (as applicable) across pre and post firmware updates. Following discussions by the parties, broadly speaking, the tests conducted fell into three categories: Agreed Tests, Claimants' Proposed Tests (disputed by the respective Lead Defendants), and Lead Defendants' Proposed Tests (disputed by the respective Claimants).

299. Shortly thereafter the Claimants notified the Lead Defendants of their designated mechanical engineering experts for each GLO. Having originally indicated an intention to rely on just one expert the scale of the job involved meant that in fact the Claimants deployed different experts across Mercedes, Nissan/Renault, PCD and Ford.

300. Testing was intended to be completed by 2 May 2025. There were delays and subsequent variations or extensions, including continuation beyond 2 May in the Nissan, Ford and PCD proceedings, and an extension to 16 May 2025 (and then further) in the Mercedes proceedings.

301. On 5 June the Renault Defendants sought permission to rely on the expert evidence of two mechanical engineering experts, Professors Plá and Benajes. That permission was granted.

302. Discussions took place later in May and June between the experts, with joint reports in June, first reports from the middle to the end of July and supplemental reports being served in August and September and second supplemental reports in late October and early November (well after trial had commenced). The delays involved put very considerable pressure on trial preparation, since skeletons had to be served well ahead of the trial start date.

303. Supplemental reports were served in August and September. In late August the Lead Defendants issued applications seeking to strike out parts of Dr Heitz's reports on the basis that he had strayed considerably outside his own expertise. That application, heard on 10-11 September 2025, substantially succeeded. The Claimants served updated amended versions of Dr Heitz's reports from late September to 11 October 2025.

304. Following rulings at and after the September hearing and at the second PTR on 6 October 2025, I ordered certain restrictions on the scope of Dr Tate's evidence and directions for revised versions of his material. The PCD application to strike out parts of Professor Martinez Botas' first report was refused.

<u>The Main Issues</u>

305. The "Core Allegations" in each case are that the manufacturers sold cars that did not comply with the requirements of the applicable regulatory regime because (at the point of first sale) they contained software that cheated or subverted the emissions control regime in the Emissions Regulation. More particularly it is said that:

    i) Each Subject Vehicle contained a defeat device ("DD"), as defined by Article 3(10) of the Emissions Regulation; and

    ii) Further, such DDs were prohibited defeat devices ("PDDs") within the meaning of Article 5(2) of the Emissions Regulation.

306. The Claimants allege that the presence of PDDs in the Subject Vehicles has led to:

    i) The sale of vehicles that do not conform to TA, because of the presence of PDDs, and so the levels of emissions of NOx in normal vehicle operation and use were and/or are higher than would have been emitted had they not been installed. That is because the PDDs reduced the effectiveness of the ECS in some or many

conditions encountered in normal vehicle operation and use, from the effectiveness of the ECS as they operated during the NEDC;

ii) Regulators, relevant authorities and the Claimants being materially misled as to the engine and emissions performance of the Subject Vehicles and the true level of NOx emissions in normal vehicle operation and use of those vehicles;

iii) Consequential legal liability under various heads, including for breach of contract (lack of satisfactory quality), deceit, breach of statutory duty, breach of manufacturer's warranty, claims under the Consumer Protection from Unfair Trading Regulations 2008 ("CPUT 2008") and/or the Consumer Credit Act 1974 ("CCA 1974"). The claims against Mercedes-Benz, BMW and Volkswagen ("VW") also allege a cartel (based in part on regulatory findings by the European Commission and the Korean Fair Trade Commission); and

iv) The Claimants suffering damage and/or loss.

v) All of the claims allege that PDDs were installed when each of the Subject Vehicles was first placed on the market and acquired by the Claimants, and that some or all of the "fixes" applied to the Subject Vehicles were also PDDs.

307. More particularly, it is said that a PDD relates to one or more of a number of adaption strategies applied to the vehicle, including but not limited to:

i) Reducing the EGR rate or switching off the EGR ("EGR reduction strategy");

ii) Reducing the frequency, or changing the timing, of the LNT regeneration ("LNT reduction strategy"); or

iii) Reducing, switching off the AdBlue dosing, or otherwise reducing the effectiveness of the SCR ("SCR reduction strategy").

308. The Claimants contend that:

i) Under Article 5(2)(a), a DD can be justified only where it is established that it strictly meets the need to avoid immediate risks of damage or accident to the engine of such a serious nature as to give rise to a specific hazard when a vehicle fitted with that DD is driven. Further, the need for a DD exists only where, at the time of TA, no other technical solution made it possible to avoid immediate risks of damage or accident to the engine, which gave rise to a specific hazard when driving the vehicle;

ii) Against this standard of justification, the Claimants contend that some DDs are simply self-evident defeat (or "cheat") devices, in that they are "*incapable of any even faintly plausible justification*" under the Article 5(2) Exceptions.

309. The backdrop to this, and the obvious example given by the Claimants, was VW's cycle recognition DD installed in its EA189 engines, which was the subject of the VW1 Litigation. That device sets the stage for the disputes now heard. Other manufacturers have been held to use similar devices which were more crude in construction: for instance another manufacturer reportedly installed a device that effected such a mode switch to much lower EGR rate after 22 minutes, the set duration of the NEDC being 20 minutes.

One key feature of these devices is that the vehicle was set up to behave differently in the test to how it behaved out of the test.

310. A variety of alleged devices of varying complexity will be considered below. One which the Claimants contend is present in every Euro 5 vehicle and probably very many Euro 6 vehicles, is the use of software which reduces the effectiveness of the ECS (generally by reducing the EGR rate, but also SCR dosing) according to the ambient temperature and/or air intake temperature, otherwise known as a "Thermal Window". Many manufacturers admit their use but allege that they are justified under the Article 5(2) Exceptions. There has been much litigation on this topic in the CJEU both before and after IP Completion Day.

311. Other devices alleged raise questions about whether calibrating aspects of the vehicle's performance to optimise performance in the NEDC amounts to a defeat device where the vehicle performs in exactly the same way outside of the NEDC test if it encounters the same conditions.

The PDD Trial and the Legal Issues

312. The purpose of this "PDD Trial" is to determine whether 20 Core Sample Vehicles ("CSVs") produced from around 2012-2017, marketed and sold by the Lead Defendants contained PDDs within the meaning of the ER, and if so, whether the presence of those PDDs gives rise to private law claims for breach of contract and breach of statutory duty. Judgment on the legal issues will bind all parties to the 13 GLOs that form part of the Pan-NOx litigation.

313. While there is a very considerable factual and expert content to the trial, the trial is notionally a Legal Issues Trial. The precise defined issues are:

    i) Whether any of the Sample Vehicles contained defeat devices when manufactured?

    ii) If so, whether those defeat devices can be justified pursuant to Article 5(2) Emissions Regulation?

    iii) Whether any of the Sample Vehicles contained defeat devices following the installation of updates?

    iv) If so, whether those defeat devices can be justified pursuant to Article 5(2) Emissions Regulation?

    v) The legal issues set out in Schedule 1 to the CMC Order (the "PDD Legal Issues");

        a) What conditions constitute the "*conditions which may reasonably be expected to be encountered in normal vehicle operation and use*" within the definition of a "defeat device" in Article 3(10) of Regulation 715/2007?

        b) What is meant by "reduces the effectiveness" of the ECS under Article 3(10)?

        c) For a defeat device to be found, does there need to be an intentional and/or impermissible purpose of causing the ECS to operate differently when it senses it is being tested?

d) Is there an obligation for an OEM to meet emission limits outside the test cycle?

e) Who has the burden of showing that the prohibition on DDs does not apply due to Article 5(2)(a)-(c)?

f) What components are within the scope of the "engine" in Article 5(2)(a)?

g) What "damage" falls within Article 5(2)(a)?

h) Is it necessary to show both protection of the engine from damage or accident, and safe operation of the vehicle? Or is either one of the conditions sufficient?

i) Is it necessary that the damage be "sudden" or "exceptional"?

j) Is there a requirement that damage relates only to "immediate risks of damage which create a specific hazard when the vehicle is driven"?

k) What is the meaning of "accident" in the context of Article 5(2)(a)?

l) What is the meaning of "for safe operation of the vehicle" in the context of Article 5(2)(a)?

m) Can the Article 5(2)(a) exception apply to a device that operates for most of the year?

n) How is the word "need" in Article 5(2)(a) to be interpreted? Should it be interpreted such that the "need" for a defeat device exists only where at the time of TA no other technical solution makes it possible to avoid damage or accident and risk?

vi) Whether any identified PDD constitutes a breach of the Emissions Regulation or any domestic legislation relied on by the Claimants?

vii) Whether any identified PDD constitutes a breach of contract?

viii) Whether the Emissions Regulation and/or any domestic legislation (if appropriate, read in conjunction with the EU provisions relied on by the Claimants) is actionable by the Claimants by way of a private law claim for breach of statutory duty?

314. The legal issues thus relate to NDC (Issue 1), RIE and whether there needs to be cycle recognition (Issues 2-3), and Art 5(2)(a) (Issues 5-11). They have been grouped together under the following headings:

i) Article 3(10) Legal Issues;

ii) Article 5(2) Legal Issues;

iii) The consequential factual issues, as to whether there are PDDs in the CSVs; and

iv) Legal consequences of PDDs.

315. A separate quantum trial has been listed for October 2026. It will resolve quantum issues in relation to the claims for breach of contract and statutory duty only. The final resolution of those issues depends upon the judgment to be handed down in this PDD Trial. Various matters relating to the quantum trial have been progressed in parallel with the PDD Trial.

316. Various other pleaded matters have not yet been set down for trial, including those relating to the deceit and CPUT claims; liability issues related to the Mercedes "voluntary updates" that received no form of TA under the FD/ER (like issues will arise against other manufacturers that have rolled out updates – whether in factory or to cars in circulation – including Ford (2 updates), PCD (4 updates) and Renault/Nissan (2 updates)); and the claim relating to the technology suppression cartel involving at least Mercedes, BMW and VW, so far as it involves factual issues which do not necessarily arise as part of this trial (i.e. the reasons for the calibration).

The Pan NOx Testing Regime

317. While this trial is, in theory, a legal issues trial, the parties were entirely agreed that it could not proceed without a good deal of factual and expert evidence. The parties were agreed that they needed to know how these engines actually performed. This led to an extremely complicated regime by which sample vehicles were selected and acquired from individual Claimants on behalf of the Claimant cohort. They were then tested both in their original configurations (by performing demanding technical software rollbacks) and updated configurations. The nature and extent of the testing was the subject of extensive debate, discussion, argument and agreement.

318. The CSVs were subject to various tests as part of a Joint Testing Program ("JTP"). The 18 November 2024 order provided for baseline NEDC testing on a dyno, pre-IPOCs. The 11 April 2025 Order provided for post-IPOC testing on the dyno and on the road at three UK testing laboratories – Horiba MIRA ("Horiba") in Nuneaton; Mahle Powertrain ("Mahle") in Northampton; and Ricardo in Shoreham-by-Sea ("Ricardo"), with a process for determining which tests were to be conducted.

319. A wide range of data, including NOx emissions data and "INCA" data from the ECUs of the CSVs showing commands and setpoints for various functionalities was collected. For the CSVs with SCR installed, both "engine-out NOx" and "tailpipe NOx" were measured, the former being the NOx emitted from the engine before SCR aftertreatment and the latter being the NOx actually emitted from the tailpipe.

320. With the exception of a baseline NEDC test, the specific tests conducted as part of the JTP varied by CSV. The tests conducted for specific CSVs are described in more detail where applicable when dealing with the particular CSV. In general terms:

    i) The dynamometer testing included:

        a) "NEDC Baseline Tests": tests intended to replicate the Type 1/NEDC tests which were used in the grant of TA for vehicles of these types;

        b) "4 x NEDC Test": the NEDC cycle is repeated 4 times sequentially, with the engine key switched off and on between the 2nd and 3rd cycles. These tests were preceded by preconditioning and soaking such that the 1st cycle was

equivalent to a NEDC Baseline Test. The later cycles are not, because the engine was heated by the previous cycles;

c) "Low Ambient Temperature NEDC Tests": the NEDC cycle in a chamber with low ambient temperature (between -5°C and 5°C depending on the test), with vehicle soaking to bring down the vehicle to that temperature before the start of the cycle;

d) "NEDC Engine Key Tests": the NEDC cycle, modified with the key switched off for c.10 seconds between the end of the urban cycles and the start of the extra-urban cycle;

e) "WLTC Correlation Tests": tests in the conditions applicable to the WLTC test (notwithstanding that none of the CSVs was subject to the WLTC test at type-approval);

f) "Deactivation Tests": tests following the NEDC cycle and replicating Type 1 conditions as closely as possible, in which the operation of one of the alleged PDDs was deactivated via modifications to relevant hardware. A Deactivation Test was performed for the CTS Device. As explained below, this test shows that this alleged device made no material difference to NOx emissions during the NEDC test.

ii) The on-road testing included (using PEMS equipment) tests conducted on the testing laboratories' official RDE test routes, in accordance with RDE requirements. They also included further testing stipulated by the Claimants and conducted according to instructions determined by their experts which included (i) tests conducted on the same routes but with different prescribed speed ranges and rates of positive acceleration to capture "conservative" and "moderate" driving styles; and (ii) for some CSVs, tests conducted on alternative driving routes, designed to include greater variation in road grade. The drivers who conducted the test were all engaged by the laboratory in question;

iii) As well as the continuous driving data collected as part of these tests, the parties recorded data from the ECU. Unfortunately, the tools used to record ECU data did not always work or could only record a limited number of data points, resulting in some gaps in the testing data.

321. As to the conduct of the testing:

i) Pursuant to the 11 April 2025 Order, relevant Lead Parties were entitled to have representatives attend each test. The Claimants retained engineers from 44 Energy to observe the tests conducted on Mercedes, PCD, Renault and Nissan CSVs and engineers from Emissions Analytics to observe the tests conducted on Ford CSVs. The Lead Defendants sent their own representatives although they did not attend every test;

ii) Instructions for dyno tests were provided to the testing centres by email, copying in the relevant Lead Parties, typically in the form of an excel schedule identifying the specific tests and when they were to be run. These schedules reflected

discussions with the testing centres about the availability of dyno testing slots and the appropriate order in which to run the proposed tests;

iii) For on-road tests, the Claimants provided each Lead Defendant with a protocol detailing the proposed routes and driving styles to be run in addition to standard RDE tests. Testing centres were often instructed as to the specific on-road tests to be run each day by email, or during a pre-test briefing in the morning). In each case, the instructions were consistent with the protocol provided to the Lead Defendants and the Defendants' representative was present or entitled to be present at the briefing.

iv) The timing and location of the tests, after various extensions was as follows: Mercedes: 14 April 2025 to 22 May 2025 at Horiba and Mahle; Ford: from 1 April 2025 to 3 June 2025 at Ricardo and Mahle; PCD: from 27 February 2025 to 13 June 2025 at Horiba and Mahle; Renault: 28 February 2025 to 30 April 2025 at Horiba and Mahle; and Nissan: from 5 March 2025 to 9 May 2025 at Horiba and Mahle.

322. All of the on-road tests were carried out in moderate or warm weather in April-May 2025. The average temperatures in which the on-road tests were carried were out in the range of 10.65℃ - 13.25℃, with a low of 8.65℃ and an alleged maximum temperature of 39.75℃ or 35.35℃. Given that the on-road testing took place in April-May 2025, and that the highest temperature recorded in June 2025 was 33℃, it is clear that some of these maximum temperatures are unreliable.

323. Despite this complicated regime there were limits to the utility of the testing. There were time constraints and practical limitations on the JTP. The parties were not able to carry out all of the tests they would have wished. Many of the mechanical engineering experts comment that it would have been preferable to have more repetition of tests to ensure consistency in the results. There are also instances of test houses not recording data they were asked to record.

324. For a number of the pleaded functionalities, there is no test from which the effect of that functionality, in isolation, on tailpipe NOx emissions can be discerned. Some pleaded functionalities (e.g. the EGR Atmospheric Pressure Correction) were not even activated in any test.

325. Further this was a somewhat aged cohort of vehicles, leading to issues about the effect of wear and tear on results; and there was not perfect clarity as to whether they were all running without faults.

326. In addition, no testing can be 100% robust. Fairly obviously a degree of variability of results, even between *prima facie* identical tests, is to be expected. Mr Day considered that a spread of +/- 10% is typical for back-to-back tests on the same chassis dynamometer and Mr Smithers accepted that the divergence could be that high. That was broadly consistent with the spread of results from NEDC Baseline Tests on the CSVs and with the parameters of the Type 1 Test. If anything, the propensity for test-to-test variability in this case may well be greater than that, because tests were conducted across multiple facilities, by various different drivers, with fluctuating conditions of temperature etc. And predictably, the propensity for variation in on-Road tests is obviously greater because the variation of conditions between such tests is likely to be greater than for

Dyno Tests. In addition, there was very limited scope for the kind of repeat testing which would normally be considered to produce robust results. A degree of caution has to be observed therefore in attaching significance to relatively small differences in test results.

Confidentiality and collateral use

327. There are confidentiality ring orders governing each GLO. There is also a Pan-Lead CRO, with a group of "Pan-Lead CRO Ring Members". This allows those members to see certain Pan Lead Documents, and the Claimants to collaterally use those documents in the Pan-Lead Proceedings (i.e. these proceedings).

328. Prior to the Trial, a De-designation Hearing ("DDH") was held between 7 and 9 July 2025, with judgment handed down by Constable J on 25 July 2025, [2025] EWHC 1931 (KB). The DDH concerned the designation as confidential of documents and materials for trial use, publication, and access, and determined the framework governing what material would be treated as public or non-public during the Trial. The Claimants made applications to de-designate pleadings, witness statements and certain disclosure documents. Third parties, including ClientEarth and Mums for Lungs, applied for access to, and de-designation of, pleadings.

329. Following the DDH, the Court ordered that pleadings and witness statements be de-designated in their entirety and also established a structured approach to confidentiality for disclosed documents. This included the use of a traffic-light system to denote the status of documents:

    i) Green: documents that are non-confidential, capable of being referred to in open court and treated as public;

    ii) Amber: documents that are confidential "in principle" and capable of being referred to in open court subject to restrictions e.g. limited quotation, anonymisation, or controlled access; and subject to a procedure whereby: (a) collateral use restrictions are only lifted in respect of the relevant part of the document quoted and not the document as a whole; and (b) the Lead Defendants will have the opportunity to apply to reinstate the full collateral use restrictions within a specified period of time;

    iii) Red: documents (or parts of documents) that are fully confidential, subject to confidentiality protections and cannot be referred to in open court. These documents remain subject to restrictions on collateral use and will not become part of the publicly accessible court record, pending the outcome of a resolution procedure at the conclusion of the trial.

330. That framework governed trial conduct throughout. Although documents with at least some red-designated material were referred to on 21 and 30 October; 3, 5 and 6 November and 2, 9 and 10 December (in total a mere 10 documents), the Court did not need to sit in private, nor was it necessary to exclude other parties, observers from the courtroom or the Opus live stream when those documents were brought up in Court. References to those documents have been redacted from the non-confidential version of the transcript. The Trial therefore took place in open court, subject to the confidentiality safeguards determined at the DDH.

331. A Position Document and accompanying draft order was approved by Bright J on 19 January 2026, which details the operation of the third-party folder, along with a process for identifying the documents to be placed into that folder. The parties continue to correspond on issues relating to whether certain documents ought to appear in the folder, but it is hoped that the parties need not trouble the Court further.

332. So far as concerns collateral use, the cases are being heard together but there are collateral use restrictions in place as against all the OEMs. This has meant that in order to collaterally use a document a special procedure was ordered by the Pan-Lead CRO. This process has involved the Claimants serving "selection notices" on the Defendants, by which the Defendants can either agree to their documents being collaterally used or contest such use.

333. The purpose of this procedure was to fulfil the Court's purpose of generating "meaningful decision[s]" that can be read across the OEMs against whom 1.6 million claims have been raised. As the Court acknowledged at the January 2024 CMC, this cannot be done without meaningful comparison between the OEMs and their strategies. The court has been clear since the beginning that the "*starting point should be openness*" and "*there's going to have to be a lot of sharing*".

The Trial

334. The evidential phase of the PDD Trial took place between 13 October 2025 and 18 December 2025, over a total of 35 full sitting days and 4 half days. After 4 days of oral openings, and 3.5 days of evidence on normal driving conditions and climatology, time during the Trial was allocated across the Lead cases approximately as follows: 6 days (Mercedes), 5.5 days (Ford), 7 days (PCD), 6 days (Renault), and 5.5 days (Nissan). The precise allocation reflected the issues arising in each Lead Case, the volume of expert and factual witness evidence in each case, and how quickly the parties considered they would be able to get through the respective material.

335. Written closing submissions were served in February 2026. Those written closing submissions ran to nearly 2,000 pages. Oral closing submissions took place over three weeks in March. The Claimants closed for 4 days, with each Lead Defendant being allocated approximately 1 day, and a further day for the Non-ALGLO Defendants, and 1.5 days of reply for the Claimants.

336. It was a great pleasure to see so much junior advocacy was accommodated. The Claimants' team, having to fight so many other parties, were particularly blessed and all of Mr Shires, Ms Buckley, Ms van der Meer, Ms Boakes, Mr Stevens and Ms Dannreuther were able to be allocated meaningful pieces of advocacy amply justifying the confidence placed in them.

<u>The Witnesses</u>

337. The following factual witnesses were called:

Claimants	None
Mercedes	None: Claimants seek adverse inferences
Ford	Dr Davies

PCD	Mr Lesueur Mr Chappelle
Renault	Mr Reverseau Mr Pineau Mr Bouchez
Nissan	Mr Miguel Mr Sauca Mr Sasot Mr Hirai Mr Brown (not called)

338. The following expert witnesses were called:

	Software	**Mechanical engineering**	**Climatology**	**Normal Driving Conditions**
Claimants	Dr Heitz	Mr Smithers Mr Carder Professor Martinez-Botas Professor Tunestål	Professor Mills	Dr Tate
Mercedes	Dr Martens	Mr Day		Professor Hausberger
Ford	Mr Migliorero	Professor Millo		
PCD	Mr Savage	Mr King		
VW			Professor Chapman	
Renault	Mr Bull Professor Plá Moreno Professor Jesus Vincente Benajes Calvo	Mr Mortimer Professor Plá Moreno Professor Benajes Calvo		
Nissan				

339. In general, the witnesses were helpful and made clear that they were trying to assist the Court. However, in relation to the factual witnesses the passage of time alone means that factual evidence had to be treated with some caution. Factual witnesses are dealt with in relation to the action in which they were called.

340. Overall the expert evidence was a privilege to listen to, since it involved gathering in one court over the weeks of the trial a real range of incredibly knowledgeable specialists. For example Mr Carder, the Claimants' expert for Ford, was one of the researchers who had identified the Dieselgate issue, Professor Martinez-Botas for the Claimants in PCD is Head of Turbomachinery at Imperial College London, while his opposite number Mr King was the Chief Engineer in the Performance Development department at the Ricardo testing house. So far as the climatology experts are concerned I considered their evidence to be some of the best, fairest and most impressive expert evidence I have ever seen.

341. Of the experts my greatest reservations concerned Mr Smithers, Dr Heitz and Professor Millo.

342. So far as Mr Smithers was concerned, I was not entirely convinced he had fully imbibed the ethos of the Part 35 expert process, this being his first experience of being a Part 35 expert in proceedings in the Court of England and Wales, while at the same time he had extensive experience of acting as an expert in cases similar to this in other jurisdictions. Specifically, he did repeatedly evidence a wish to get onto the bits of evidence he wanted to talk about, regardless of the question he had been asked. He had a tendency to look for any qualification rather than accepting fairly obvious propositions. This was evident in his qualifications to answers to questions which appeared to call for unqualified acceptance (for example because they reflected evidence he himself had previously given in another case) and in the not infrequent interposition of a long pause before answering any question with a more or less unqualified agreement. For example he gave a long pause before answering the fairly obvious – e.g. higher engine loads can be encountered any time of the year or before accepting that "probably" even as a matter of generality, constant speed driving would generally lead to lower emissions than transient driving because steady state conditions are less challenging for an emission system.

343. Another example was when he essentially refused to agree that it is not the case that in every conceivable circumstance any change in an EGR rate of whatever size will lead to increased Nox. His response to this proposition was, after a long pause and some preparatory hesitation to say "*I don't want to answer and give too much weight to these other sort of extenuating circumstances that can also influence the NOx number…*".

344. Dr Heitz also has a long history of acting as a claimant side expert and no prior experience of being a Part 35 expert. That did show. There was the unfortunate episode in the run up to the trial relating to his report: he had approached his original work as one of searching for PDDs, and he had read his instructions expansively leading to a situation where he strayed outside of the areas where his expertise interlocked with that of the mechanical experts. This led to the situation where I ruled shortly before trial that large parts of his expert report must be struck out as not apt for a software expert. Time did not permit me to rule on the precise passages to be removed, but it was plain from the ruling that I expected large parts of the report to be excised, reflecting the division between his own expert discipline and that of the mechanical engineers. However they were not – on the basis that Dr Heitz continued (despite my ruling) to hold the view that the software aspects could not be properly addressed without an analysis (by him) of the various aspects of the mechanical engineering issues. This mindset remained evident in his response to the striking out of parts of his report, where he remained (genially) completely unrepentant saying "*I'm still of the opinion that my report in the unredacted version is easier to understand and complete and the redacted version is missing essential details…*".

345. In person however he generally presented as far less dogmatic than might have been expected given this background. Indeed he did not overtly seem at all to be someone fighting a corner, with a genial approach and a ready smile. Despite the issues which I have found with his evidence I do not accept the criticism that he was not trying to be an independent expert assisting the Court. It did however seem to me that he had developed a deep, verging on passionate, interest in the issues which at times deprived him of the degree of objectivity which is the stance of the most helpful evidence. For example his evidence in Nissan involved a passage of arms whereby, while ultimately accepting some errors as to his approach as to LNT regeneration, he was bouncing up and down in his seat while he explained why he felt counting failed regenerations was not serious but rather a distraction from what he saw as important. Nissan's characterisation of him as seeming even more committed to the case than the Claimants themselves – hanging on to allegations (such as glow plugs) even when they had been dropped – was very apt.

346. There was also an appearance that he had relied quite heavily on his "team", none of whom were Part 35 experts – thus in one case an internal note from his team arguing for a "best case" result was left in the report when served.

347. Professor Millo appeared perhaps to have relied too much on Mr Migliorero, who had been his student and with whom he had previously worked closely. Further, while in person he was a perfectly reasonable and fair witness, it appeared that his report had been drafted to a dogmatic style not often seen in the English Court, which contained some inaccuracies and which did not fully reflect the nuance of his views, which as a Part 35 expert he was expected to (and did in person) give. Although his English was excellent and he waived reliance on an interpreter some of his answers appeared to betray that he had not fully followed the question. This perhaps contributed to passages of his evidence which were a little dogmatic and defensive. He also exhibited something of a tendency not to focus on the question, with Mr Moody KC (in a last, skilful re-examination before his own exit to the High Court bench) having to bring him back to the question asked.

348. Mr Carder, the Claimants' mechanical expert for Ford, was an acute and jovial witness of obvious reasonableness. Despite an appearance of being easygoing, he was plainly extremely intelligent and focussed. He listened carefully to questions - on one occasion to the extent of recalling a question more or less verbatim without looking at the transcript after listening to a lengthy dispute between counsel about the appropriateness of the question. Aside from the merits of his evidence, he brought a ready sympathy for the Court's dilemmas in this case and a level of wit not often exhibited in cross-examination.

349. Professor Martinez-Botas was also a very reasonable witness (on occasion too much so for the Claimants' case), since he was careful not to criticise on-the-ground engineers, and scrupulously maintained the distinction between academic work and calibration in practice.

350. As for the Defendants' other expert witnesses, Mr Day was a calm, deceptively serious looking witness who stood up to lengthy cross examination by two leading counsel with scrupulous care and enlivening gleams of humour, including gently chiding Mr de la Mare KC for persisting in using exclusionary language (Latin), or (at the end of the third day of evidence) "*sorry, my ears worked, my voice didn't*". He listened with the utmost care to the questions put to him, made appropriate agreements and answered in clear non-technical language, at no greater length than was appropriate. It was put to him (and later submitted) that he was a hired gun, acting solely or predominantly for manufacturers. I

reject that submission. Mr Day was plainly a fair, careful witness doing his best to assist the Court. At the same time the balance of the work which he had done, as an experienced industry engineer often working in calibration for manufacturers, necessarily had an input into his very genuine opinions when it came to matters such as the balancing of competing factors and the scope for engineering judgment.

351. Mr Bull, the Nissan defendants' software expert, was down to earth and laconic, delivering answers often in the form of: "yes", "not correct", and "I believe so". That may in part owe something to Mr Stevens' exemplary focussed questions.

352. One thing which became apparent during the course of trial was the inherent issues in testing such complex and wide-ranging expert evidence via cross examination. Although a huge amount of work had been put in by both experts and counsel, the sheer level of complexity and the individual complications which arose in relation to a wide range of vehicles created situations where it was apparent either that an answer given by an expert was one which was not instantaneously perfectly comprehended by the counsel team or that the very detailed granular questions being asked took the expert beyond the limit of what they were able to hold in their head. There were also a number of situations where an expert (in particular Mr Smithers) gave evidence based on a development of their thinking or reading beyond what was encapsulated in the served expert evidence. So at times it was apparent that issues could not be fully explored.

Adverse Inferences

353. The Claimants have invited the Court to draw adverse inferences – in particular against Mercedes based on a failure to call factual witnesses. A lengthy section of the closing was devoted to this topic. The relevant authority here is *Royal Mail Group Limited v Efobi* [2021] UKSC 33 [2021] 1 WLR 3863 which deprecated an over prescriptive approach to the drawing of inferences, instead emphasising a common sense approach based on relevant considerations such as the context of the proceedings, the availability of the absent witness, what relevant evidence the absent witness could reasonably be expected to give, the state of other relevant evidence on those points, and the significance of those points in the context of the case as a whole. The importance of identifying the precise adverse inferences sought to be drawn was emphasised.

354. The vast majority of the inferences which the Claimants seek to have drawn are wide and vague and completely unrelated to particular witnesses. An example (one of the eight inferences sought to be drawn) was as follows:

> "In Euro 5 Mercedes' calibration philosophy was to maximise EGR use to the extent required to pass the NEDC with some 'headroom' whilst still generating optimal fuel consumption figures on the NEDC test; but substantially to reduce the use of EGR outside the NEDC zone not solely for safety concerns but primarily to maximise real world fuel economy; to reduce NVH; to increase sportiness/performance to a level consistent with the Mercedes marque, so long as NOx emissions off cycle were controlled to the extent required to obtain 3 stars on the Swiss Touring Cycle test."

355. I have no hesitation in saying that the inferences as set out are completely inappropriate and I decline to draw them. However the judgment will on occasion below focus down on a particular issue and the drawing of a specific inference in that context.

Open Justice

356. There has been significant interest in the proceedings from third parties. To facilitate transparency and access, the Court arranged for the trial to be heard in a super Court, and for an overflow courtroom to be set up at the RCJ. Each Court was equipped with large EPE screens which displayed documents as they were shown on the Opus platform, along with a live video link that enabled real-time observation of the proceedings.

357. Additionally, the parties were granted permission to livestream the trial to pre-identified individuals, including party representatives joining remotely of three main interested third parties (these being ClientEarth, the Scottish NoX Emissions Steering Group, and Birkway), in addition to the Claimants, non-Lead Claimant firms, funders, insurers, advisers linked to the Defendants, and interested members of the public, enabling them to follow the proceedings and view documents called up on screen contemporaneously. These arrangements ensured that the Trial was accessible to parties and non-parties alike. With the assistance of the parties and their advisers this meant that it was possible to accommodate interest in the proceedings meaningfully while maintaining the orderly conduct of the Trial.

358. As of 18 December 2025, 26 third parties (including journalists) had requested access to documents referred to at the PDD Trial, and 19 requested access to transcripts. Following extensive discussion and co-operation, the parties have agreed that a folder containing documents referred to at trial will be shared with those third parties who have requested documents. The folder is being managed and facilitated by the Claimants on instruction from the Court.

THE ALLEGED DEFEAT DEVICES: SUMMARY

359. This case is unique in the history of diesel defeat device litigation in that it has enabled a single court to consider not just a wider range of alleged defeat devices than any previous case has done, but also variations on the alleged defeat devices in different manufacturers' vehicles.

360. As noted above the CJEU has considered the VW cycle recognition/switch DD and it has also considered (separately) thermal and altitude windows. Only national courts have considered torque/speed windows. Timer devices are entirely new. So too are all the devices which concern non-EGR DDs.

361. Further the vast majority of previous decisions have taken place on the basis either of agreed facts (for preliminary determinations) or of very limited factual and expert evidence.

362. Thus it has been possible to consider the legal issues not simply against the background of a single alleged defeat device (such as a thermal window 18-35°C) but against the gamut of simple devices such as the "vanilla" ambient air temperature window via the more sophisticated variants of this (intake air temperature causing a switch of EGR mode, rather than a derating) all the way through to devices of such sophistication that a cold towel is an advisable adjunct to reading about them.

EGR DDs

363. The alleged EGR DDs cover a number of different sub-types, of which the main varieties are:

    i) Thermal windows;

    ii) Atmospheric pressure DDs;

    iii) Torque/speed DDs;

    iv) Delayed LP EGR DDs;

    v) MAFSP DDs;

    vi) Torque cut-off DDs;

    vii) EGR Rate Manipulation DDs; and

    viii) Coolant Temperature DDs.

Thermal (temperature) windows

364. Thermal windows are deceptively simple. As alleged and as described in some of the prior judgments they comprise a range of temperatures within which EGR is fully operational with EGR systems being either switched off, or derated (gradually or precipitously) outside of those windows.

365. One complication arises from the accepted fact that the EGR rate must be reduced at low and high temperatures in order to preserve combustion stability and to deal with overheat and soot production at high temperatures. Any driver will readily be able to comprehend that given the greater demands on the engine at such high and low points, reducing the richness of the mix being used (the effect of EGR) risks leading to very unstable or failing combustion. Or as Professor Millo explained (in evidence accepted by Mr Carder) running EGR at low ambient temperatures can adversely impact combustion. This is because colder ambient conditions contribute to colder temperatures within the combustion chamber at which it is more difficult to cause compression ignition. Further, colder air is denser. To maintain a constant target mass of fresh air for stable combustion the ECU necessarily needs to account for the increased density which in turn impacts the available volume for EGR.

366. Given that one ends up at this position, it then becomes a question of at what point, and how suddenly, it is acceptable for EGR to be adjusted. Further the reality is that calibrators will "radiate outwards" from the NEDC conditions.

367. However thermal window arguments actually involve considerable definition of terms, because in most vehicles there are multiple different temperature sensor locations and a window defined by reference to one sensor's results may well be very different in effect to an apparently identical window defined by reference to a different sensor's results.

368. The possible temperature sources in focus were: (i) ambient air temperature outside the vehicle ("AAT"); (ii) intake air just after the fresh air has come in to the intake pipe and

before it passes through the compressor ("IAT"); (iii) charge air temperature after the compressor and intercooler but before entry into the combustion chamber ("CAT"); (iv) engine coolant temperature taken of the coolant that flows to and exchanges heat with the combustion chamber ("ECT"); and (v) engine oil temperature ("EOT").

369. These temperatures obviously have some sort of relationship to each other; but that relationship defies easy definition and manufacturers may modulate by reference to different ones across different vehicles.

i) AAT: is the only straightforward one;

ii) IAT: should not be assumed to be the same as AAT. IAT is often said to be c.5°C higher than AAT. That however is only a rule of thumb. It is probably about right after the vehicle has been running for a while. But the relationship is non linear: IAT and AAT will be the same at key-on after temperature soaking. The difference will be affected by the extant heat of the engine and driving patterns (especially idling or low speed with a hot engine). Having said all that the Claimants have accepted in their written closing that "generally speaking AAT = IAT - 5°C.";

iii) CAT: bears a relationship to AAT, but will (self-evidently) usually be higher than AAT. The experts were broadly in agreement that the divergence would be in the region of 10-15ºC;

iv) ECT: Engine Coolant Temperature. The temperature of the coolant circulating around the engine and other components requiring cooling, including the EGR system;

v) EOT: Engine Out Temperature. This is the final temperature which is discussed in the context of Thermal Windows. However it is discussed as a comparator. There are no alleged PDDs defined by reference to it.

370. In closing, the Claimants summarised the alleged EGR DDs as set out in the table which follows. Green shading indicates devices fully within the Claimants' case as to NDC temperatures (i.e. for the Claimants defeat devices throughout their range of operation), blue indicates they are partially within that range. Grey shading indicates devices that are not challenged by the Claimants as they operate outside the Claimants' case as to NDC temperature conditions. (For the purposes of comparison, the temperature window in *GSMB Invest* was 15/33 with a linear decrease to zero at -5°C).

CSV	*Temperature measure*	*Lower EGR shut off (°C)*	*Window with no Air Temp. Derate (°C)*	*Upper EGR shut off (°C)*
EURO 5				
MBC1	ambient		15 to 30/35 (for CTS)	
MBC1 update	ambient		0 to 40	
FC1	IAT	<-10	5 to 30	40
FC5	IAT	-5	15 to 35	60
FD3	IAT	4.96	17.96 to 134.96	>134.96

CSV	*Temperature measure*	*Lower EGR shut off (°C)*	*Window with no Air Temp. Derate (°C)*	*Upper EGR shut off (°C)*
PCDC6	IAT	-10	5 to 40	60/65
PCDD4	IAT	-10	5 to 50/55	50/55
NC1	IAT	5/7	17 to 33/35	33/35°C
RC3	IAT	-30/-28	17 to 43/45	43/45
EURO 6				
MBD1	ambient		10 to 37	
MBD1 update	ambient		5 to 55	
MBC6	CAT		20 to 30	
MBC6 update	CAT		≤ 50	
MBD6	CAT		20-47	
MBD6 update	CAT		≤ 50	
FC6 (base and update)	IAT	-10.04	≥ 4.96	N/A
FD1 (base)	IAT	-20.04	≥ 14.96	N/A
FD1 (update)	IAT	-20.04	≥ 19.96	N/A
PCDC3, PCDD1 without Kaizen-NOx update	ambient	-10	17/19 to 30/32	65
PCDC3, PCDD1 Kaizen-NOx update	ambient	-10	7/9 to 30/32	65
PCDC3, PCDD1 Kaizen-NOx -2 update	ambient	-10	-2/0 to 30/32	65
NC2	IAT	-21/-20	17 to 37/39	37/39
NC2 update	IAT/ambient	-21/-20	8 (AAT) to 43/45 (IAT)	43/45
RC2	IAT	-21/-20	17 (AAT) to 36/38 (IAT)	36/38
RC2 update	IAT	-21/-20	8 (AAT) to 43/45 (IAT)	43/45
RD2	IAT/ambient	-21/-20	3 (AAT) to 56/80 (IAT)	58/60 (IAT)

371. It will readily be perceived that, given the points made above, the viability of a number of these pleaded allegations are dependent on the range for NDC. Lower temperature derating figures are often at about (or if IAT is given any potential allowance by reference to a delta between it and AAT) below the bottom of the NDC range contended for by the Defendants.

Atmospheric Pressure DDs

372. In closing the Claimants summarised the alleged Atmospheric Pressure DDs as follows:

CSV	*Derating starts (hPa)*	*Approx. equivalent altitude (m)*	*EGR shut off (hPa)*	*Approx. equivalent altitude (m)*
EURO 5				
FD3	<950	~500	853	~1500
PCDC6	930	~700	840	~1600
PCDD4	925	~750	875	~1250
MBC1 (original and	925	~750		

CSV	*Derating starts (hPa)*	*Approx. equivalent altitude (m)*	*EGR shut off (hPa)*	*Approx. equivalent altitude (m)*
update)				
FC1	<900	~1000	850	~1500
FC5	<900	~1000	825	~1800
NC1, RC3 (Original and update)	N/a		890/900	~1100/~1000
EURO 6				
MBD1 (original and update)	950	~550		
MBC6 (original and update), MBD6 (original and update)	950	~550	850/500	~1500/~5500
FC6 (base)	<950	~500	850	~1500
FC6 (update)	<950	~500	925	~750
FD1 (base and update)	<950	~500	850	~1500
PCDC3, PCDD1 (original and after updates)	930/940	~500/750	750	~2500
RC2 (original and update), NC2 (original and update), ND1, RD2,	N/a		890/900	~1100/~1000

373. There are a number of issues which potentially come into play here.

i) The first is the determination of the appropriate atmospheric cut-off for NDC;

ii) The second is given that, and the evidence from the majority of the mechanical engineering experts that adjustments had to be made to maintain combustion stability at high altitudes and their broad agreement that the figures settled on were ones of judgment and that the figures in fact settled upon were within the range of figures regarded as acceptable, whether that has an impact on any allowance;

iii) The third is the absence of JTP testing underpinning these alleged PDDs and how RIE is then to be judged;

iv) The fourth is justification which is alleged largely on safety grounds if there was a PDD.

<u>Torque/Speed DDs</u>

374. All OEMs de-rate or cut EGR above certain torques and engine speeds. To some extent there will be engineering reasons for this derived from these factors alone because:

i) At high engine speeds there is less time available for combustion, so more oxygen (i.e. more fresh air) is required to allow efficient combustion;

ii) To deliver high torques the engine needs to burn more fuel, and so requires more oxygen.

375. On the NEDC, EGR is not substantially cut or derated. Outside that engine speed/torque area however, EGR is derated or cut before the maximum torque curve of the vehicle.

376. The Claimants' case is that any derating of EGR before the maximum torque curve of the vehicle is a PDD and that the full range of torque and engine speed are used in normal driving. Or to put it more colloquially and understandably: that "pedal to the metal" acceleration is normal driving conditions, subject only to a marginal derogation for "boy racer"/dangerous and illegal driving.

377. The Defendants' positions are much more complicated and nuanced invoking some of the other factors which intersect with torque, speed and EGR. In particular there is consideration of the impact of:

    i) Ambient air temperature and coolant temperature, because in colder conditions more fresh air is required to enable stable combustion and to control emissions other than NOx;

    ii) Combinations of these conditions, because the challenge to emissions control and combustion increases if both torque and engine speed are high, and increases still further if it is also cold.

Delayed LP/HP EGR Switch DDs

378. This alleged DD is peculiar to Renault/Nissan vehicles. The Claimants contend that the Renault and Nissan vehicles operated a DD by which there was a switch from (more effective) LP EGR to (less effective) HP EGR at the following temperatures:

CSV	*LGR cut off (HP EGR only below this temperature)*	
	Temperature measure	*Switching temperature*
EURO 5		
RC3 and NC1	IAT	17
EURO 6		
RC2	ambient	17
NC2	IAT	17
RC2 and NC2 update	ambient	8
RD2	ambient	3
ND1	ambient	8

Engine/Coolant Temperature DDs

379. The Claimants' case is that Mercedes, PCD and Renault used parameters linked to the engine temperature for their DDs, either by reference to engine coolant temperature or engine oil temperature.

380. The coolant is glycerated water that runs around a piping system pathway around the combustion chamber and any other systems that need cooling (such as the EGR). The normal profile of coolant temperature during a journey with a cold start is that it starts

low, takes a while to get to normal operating temperature (some minutes), and then is maintained there by a thermostat and radiator. The time taken to get to normal operating temperature will vary, although during the NEDC (given the fixed starting temperature and precisely standardised load), the time to reach any particular coolant temperature will be the same for each vehicle so a coolant temperature trigger operates as a timer. Oil temperature follows a similar pattern and broadly tracks coolant temperature.

381. Nissan and Renault cut EGR below a certain ECT (20/60°C) in certain circumstances and have a minimum ECT threshold for the operation of LP EGR.

382. PCD's Euro 6 CSVs have two modes of operation. LowNOx mode only applies if three conditions (ambient temperature, atmosphere pressure and vehicle speed) are all met simultaneously, otherwise Low CO^2 mode applies. This is just a combination of three boundary PDDs and can be treated in much the same way.

Torque Cut-Off DDs

383. All manufacturers de-rate or cut EGR above certain torques and engine speeds. The broad nature of the DD allegation is that calibrations ensure that on the NEDC, EGR is not substantially cut or derated; but outside that engine speed/torque area, EGR is derated or cut before the maximum torque curve of the vehicle.

Engine Temperature DDs

384. It is alleged that Mercedes, PCD and Nissan/Renault used parameters linked to the engine temperature for their DDs, either by reference to engine coolant temperature or engine oil temperature. In particular it is said that because during the NEDC (given the fixed starting temperature and precisely standardised load), the time to reach any particular coolant temperature will be the same for each vehicle so a coolant temperature trigger can be operated as a timer to trigger differential engine behaviour.

LNT DDs

385. These are alleged in relation to Ford, Renault and Nissan only. The allegation is that these manufacturers deliberately programmed the LNTs to regenerate at predefined, specific points during the NEDC test and the preconditioning for the test. The LNTs were calibrated to regenerate in the EUDC, both during the preparatory drive of pre-conditioning and the NEDC test. As a result the LNTs were fully purged in advance of the NEDC test and then purged at an optimum point in the EUDC, rendering the LNT most effective for the high speed and high load portion of the NEDC test.

386. The "headline" allegation here is that as a result of the programming the LNTs regenerated optimally in the NEDC test, but would not regenerate at all or remotely adequately when driven in urban conditions (which will be the sole or dominant driving conditions for a significant number of drivers).

SCR DDs

387. These are alleged against Mercedes, Ford and PCD. The allegation here is in some ways similar to the LNT allegation:

i) Mercedes and PCD used similar SCR strategies involving two primary dosing modes: one which was more efficient and always applied in the NEDC (in PCD's case, via a sub-mode that never appeared in real world driving) and another mode, designed to save consumption, which was less efficient and never applied in the NEDC and, in the case of PCD, applied as the default or nominal mode in the real world;

ii) Ford's SCR strategy modulated the urea dosing such that the quantity of AdBlue injected into the exhaust system was restricted to a urea dosing limit ("UDL"), the effect of which was that in real world driving conditions insufficient AdBlue would be dosed to treat the NOx emissions.

The split injection DD (PCD)

388. The split injection DD is the only DD that does not concern EGR, LNT or SCR and is alleged only against PCD. It is alleged to involve the application of a mode which recognises the EUDC phase of the cycle, and which then applies fuel injection settings which reduce NOx emissions.

Claimants' Backstop A: The global or aggregate approach to PDDs

389. Having identified and pleaded a fairly large number of PDDs, each of which is alleged to be a PDD, the Claimants offer a backstop. They submit that even if the Court is not satisfied that any given alleged PDD is proved, its effect needs to be considered together with other alleged PDDs, and that Alleged PDD A + Alleged PDD B may together amount to an actual PDD. Thus it is said for example in relation to PCD's split mode, that it must be considered alongside the other DDs, including the combustion mode DD, with which it operated in conjunction. As a package, it is said, they were highly material in their RIE.

390. The Defendants maintained that the case had to be decided by reference to pleaded individual PDD allegations, not a later-developed aggregate theory. The Mercedes Defendants stressed that the PDD trial was to be conducted by reference to the evidence and issues pleaded in each separate GLO and that Claimants should be confined to their pleaded case.

391. The Defendants' position on this is correct. The aggregate approach is not the way the case was pleaded, and it is not satisfactory at the close of a trial to effectively invite the Court to go off by itself and reiterate individual arguments into a variety of compendious arguments. Still less so is this acceptable when the effects of the combination had not been investigated technically. The Claimants have had the opportunity to decide on their case. They have had the chance to plead alleged PDDs which are as simple or as complicated as they have wished. It is those identified PDDs which form the subject matter of the rulings in this judgment.

Claimants' Backstop B: The Claimants' case on CRDDs

392. The Claimants' case was that if (very much contrary to their submission) the only prohibition is one against CRDDs, then the following devices meet that definition:

i) Mercedes' CTS Device, on the basis that it is alleged that:

a) MBC1 was programmed to maintain an artificially low coolant temperature, which had the effect of: (i) reducing engine-out NOx; and (ii) delaying the activation of EGR derates based on engine oil or coolant temperature;

b) The CTS will always activate in the NEDC, but will not often activate in most other NDC. For example, it will never activate outside of a 15-30°C AAT thermal window; or when the engine is warm (i.e. when engine oil is above 61°C); or at high loads or engine speeds; or after a timer set by reference to oil temperature on ignition (unsurprisingly, programmed by Mercedes to operate just long enough for the NEDC at 20-30°C).

ii) Ford, Renault and Nissan's LNT CRDD, on the basis that it is alleged that:

a) The Ford, Renault and Nissan Defendants calibrated the LNT rules to ensure that the LNT purged at precise, specified and predefined points in the preconditioning phase and the EUDC phase of the NEDC test calibrating the LNT purges to the precise contours of that cycle;

b) The LNT was fully purged in advance of the NEDC and then purged at the optimum point of the NEDC test (during pre-selected points, defined down to the second in the high speed and high load portion of the EUDC where most NOx is produced) whereas outside the NEDC, the LNT did not regenerate in many NDC (including in urban driving conditions) or regenerated infrequently and/or inefficiently.

iii) PCD's split injection CRDD, on the basis that it is alleged that:

a) The ECS is programmed in the Euro 5 CSVs to trigger a special split injection mode during the EUDC phase of the NEDC, which is recognised when seven parameters are satisfied simultaneously to deliver lower levels of tailpipe NOx emissions during the test;

b) Outside the NEDC, the triggering and duration of split mode are deliberately limited by various means, including (for PCDC6) mode prioritisation, and for both CSVs, a kill switch and a timer to cap the maximum duration per drive at 110 or 120 seconds or less.

iv) In opening: PCD's SCR CRDD, on the basis that it is alleged that:

a) In the Euro 6 CSVs, the detection of the driving pattern of the EUDC triggers various behaviours which reduced NOx emissions during preconditioning and throughout the NEDC test, including the suspension of the application of Controlled Consumption Mode ("CCM"), higher AdBlue dosing limits, and a lower minimum temperature at which AdBlue dosing was permitted.

b) These behaviours were never triggered outside the NEDC.

It is fair to say that the outlines of the PCD SCR case have changed, such that the only CRDD now alleged is an unpleaded one. The case as to CCM itself is now said simply to be a PDD, not a CRDD.

393. There were also certain boundary devices alleged, albeit tacitly. These were:

i) A variety of the thermal and pressure window DDs;

ii) Some Torque cut-off strategies;

iii) ECT based EGR delays.

iv) Temperature range or consumption based SCR dosing strategies.

THE LEGAL ISSUES: OVERARCHING CONCLUSIONS

394. Before embarking on a consideration of the legal issues it is important to put down a marker as to the overall exercise.

395. The first is that this is not an easy exercise. Authorities which have previously encountered this wording have expressed somewhat negative views about its quality and clarity. Thus for example the German Federal Motor Transport Authority's Commission of Inquiry into the Dieselgate affair stated in terms:

> "The Regulation (EC) No. 715/2007 contains two specifications which are unclear and, therefore allow varying interpretations in terms of the application of the regulation…
>
> A more precise wording of the European regulations is necessary so that they can be applied and monitored without any further ado. The regulations governing defeat devices which have been applicable so far cause legal uncertainties among manufacturers and are not a sufficient basis to help type approval authorities to distinguish between lawful and unlawful defeat devices and to take legal action against the latter."

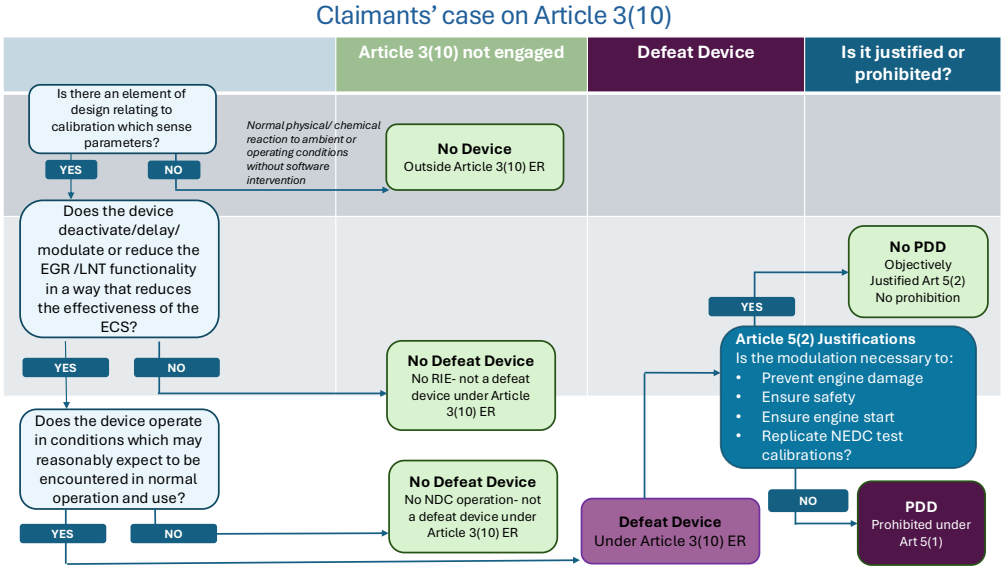
396. What follows is necessarily a series of separate analyses of individual sub issues. It is very easy to get sucked into this way of looking at the process. But ultimately the aim is a construction of the overall Articles together, as a cohesive whole. The definition in Article 3(10) must not just work by itself, it must work with the exceptions in Article 5(2). And it must work not just analytically but in practical terms. The ER introduces a scheme which must be capable of being comprehended, applied and compliance assessed. Thus the practical implications of particular arguments will at points necessarily enter into the process.

Article 3(10) issues

<u>The structure and arguments</u>

397. At the core of this case is a significant disjunction between the parties even as to the structure of the arguments. The Claimants' submission was that each stage of the legal issues needs to be broken down and separately considered. Thus for the Claimants, the answer to PDD Legal Issue 1 (whether any of the vehicles contained defeat devices) involves two contentious stages which themselves break down into segments. The first contentious stage is one of statutory construction and law as to the correct approach to "*conditions which may reasonably be expected to be encountered in normal vehicle operation and use*". This was referred to as "normal driving conditions" or "NDC". The Claimants then go on to consider reduction in effectiveness by reference to a comparison

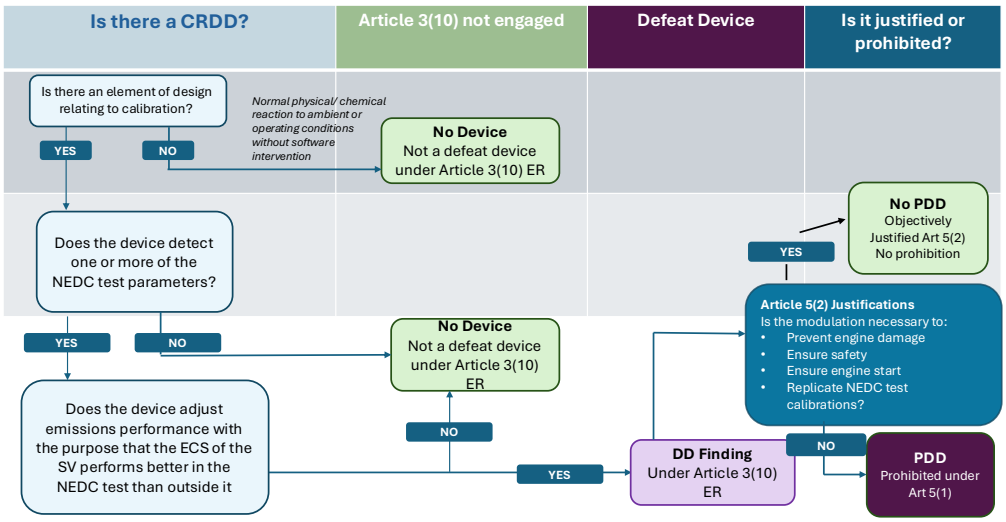
with actual effectiveness of the ECS in the NEDC against actual effectiveness in non NEDC NDCs. This approach slightly sidelines the initial parts of the definition relating to elements of design sensing parameters. It may be approximately portrayed thus[6]:



398. For most of the Defendants this disjunctive approach was deprecated, and sensing parameters was much more important. For them the primary position is that Article 3(10) is asking an altogether simpler question, where the reduction in effectiveness and normal driving conditions concepts are simply aspects which enable the decision-maker to judge whether the testing regime is being subverted – whether there is a sensing of parameters with a purpose of defeating the regime. This approach is focussed on test cycle recognition, though they differ as to the precise question. For Mercedes, it is whether the ECS senses when the vehicle is being tested and causes differential operation in that scenario compared to when it is not. For Ford the question is: is the calibration "cheating" or "defeating" the NEDC test and that is to be judged by looking at NEDC run with and without the alleged device or calibration. In overall approach this may be approximately portrayed thus:

[6] Thanks are here owed to Ms Howard KC whose original versions have been slightly adapted to fit the judgment.

CRDD approach to Article 3(10)



399. Overall by the end of the case, it appeared that there were essentially four approaches to be considered:

i) The Claimants' approach which (following a route via Article 5(2) and relying on the EU authorities) contended that Article 3(10) encapsulated a requirement that the way the vehicle performed in the test be essentially replicated in the real world. There are a variety of iterations of this approach which will be considered in due course;

ii) The Mercedes approach which contended that Article 3(10) was aimed at cycle recognition devices only;

iii) The original Ford approach which agreed that Article 3(10) principally aimed at cycle recognition devices, plus also what were termed as "boundary devices" i.e. devices which did not recognise the test per se but rather recognised the vicinity of the test. However, by closing Ford did not push this approach, whereas the Claimants were suggesting it as the most acceptable approach to CRDD analysis;

iv) The approach adopted as a back-up by many of the manufacturers, and as a sole case by Renault: the Holistic Approach. This advocated a joined up approach to pollutants and emissions, looking at the relevant factors or metrics for effectiveness as covering (at least) all regulated emissions and also how they are to be balanced with the system working well. In closing Mr Antelme KC memorably deployed the analogy of a general anaesthetic as regards an emissions strategy looking only to one pollutant at a time: an anaesthetic, he says, cannot be judged to be wholly successful if, while it does make the patient unconscious, also leaves her unable to walk for three weeks afterwards.

400. As has already been adverted to the drafting of the relevant provisions has not met with universal (or possibly any) acclaim. It is therefore perhaps not a surprise to find that each of these approaches has, when translated into the hurly burly of real life, considerable practical or conceptual difficulties. Those difficulties must be of significance when approaching the exercise of construction since part of the exercise of construction will

involve considering not just literal meaning but also context and purpose which may involve panning out to the implications of a particular approach.

401. The sub-sections which follow therefore look at the various issues which have been raised as aspects of this argument and specifically highlight the areas of debate. In some but not all contexts a conclusion will be reached as to what the answer is on a particular sub-issue. But on the whole analysis is held over to the end of this consideration.

Legal Issue 1: Normal Driving Conditions (NDC)

Introduction and overview

402. NDC is a question of acute importance if the Claimants' approach to construction is correct. On that basis NDC operates as an important element of the application of the PDD regime – and potentially an important limit. If the correct analysis is the CRDD approach however the argument has little application.

403. Before passing to the arguments it is again pertinent to note that the BMVI Report also critiqued this element of the Regulation in the following terms:

> "The fact that the constituent element of "normal use" is linguistically very vague allows room for interpretation, …
>
> It would have been advisable that the European legislature had specified and explained the constituent element of "normal use", with regard to what it entails and how such "normal use" is to be simulated. It would have seemed reasonable then to describe and specify the framework conditions of "normal use" in greater detail in order to enable approval authorities - … to apply this norm in a practical way. In particular, this concerns rules regarding which engine operating range is to be considered as normal and under which external conditions this operation has to take place, as well as specifications of whether and to which degree unusual operating conditions have to be understood as being part of "normal use", e.g. cold starts, driving in winter temperatures, or driving at high altitudes. However, relevant implementing rules have not been adopted …."

404. The parties' submissions focussed on two parts of the DD test: (a) what can "*reasonably be expected to be encountered*"; while (b) *"the vehicle is subject to normal operation and use"*. It will readily be perceived that there are issues as to reasonableness and whether normal correlates to "*not abnormal*" or something else. There are also issues as to whether this test is properly to be regarded as disjunctive and as to the precise interaction of the words *"normal" "expected"* and "*reasonably*". In addition, there is a positive wealth of issues relating to particular parts of the spectrum of conditions which might or might not be categorised as "*normal*". The consideration is complicated by the fact that the range of debate is informed by where the next stage goes – so one cannot sensibly consider these construction issues without situating them within the kinds of issues which arise at Stage 2, or indeed the range of possibilities as to the meaning of "*reduction in effectiveness*".

405. On this issue the exercise might well be expected to be (and in most of the existing cases has been treated as) to some extent one of judicial common sense. Everyone instinctively has a view as to what sort of journeys are normal, what sorts of temperatures are

reasonably to be expected, where the line lies as to aggressive but normal driving and abnormal "*boy racer*" behaviour. However, it is unlikely that anyone could, simply based on common sense, have isolated and elucidated the range of questions and the data available to provide potential answers. Many of those involved in the case were to some extent sceptical as to the idea of expert evidence on climatology and normal driving conditions, but ultimately there has been (a considerable amount of) genuinely interesting expert evidence from Dr Tate and Professor Hausberger on the types of normal driving and Professor Mills and Professor Chapman on climatology (with extra input from Professor Pope, a colleague of Professor Chapman, who assisted the Vauxhall Defendants).

406. Having said that, a position whereby four experts were called, further experts employed, and a week of trial was used to evaluate this point appeared to be a classic example of the overkill which has been apparent throughout this piece of litigation. An example of this was the slightly surreal situation where Professor Chapman was saying:

> "Q. You accept it's a normal use of a car to drive it to a second home?
>
> A. I would -- is it normal to have a second home, I think is the question in itself.
>
> Q. Assuming one has a second home, would it be normal to drive to a second home?
>
> A. If I had a second home, I think it would be very normal for me to drive to my second home, yes. Unfortunately I don't have a second home and I do consider myself to be normal."

407. As a result, far too much time could be spent delving into the evidence. I will instead commence by outlining some of the debates which had to be had in the course of the evidence, starting with the obvious questions and then identifying the sub-issues via which light was shed on the main issue:

    i) What AAT may reasonably be expected to be encountered in normal vehicle operation and use? What altitude may reasonably be expected to be encountered in normal vehicle operation and use?

        a) What is the relevant territorial scope – EU or UK?

        b) How often do such temperatures/altitudes need to be encountered and by how many people?

    ii) Is averaging appropriate – and if so, should averaging be at national or supra national level? To what extent does averaging mislead as well as elucidate?

        a) Should one take account of where people drive? Is evidence of population density a good proxy for this?

        b) Should one take account of the times of day when most driving is done (rush hours)?

c) Should one take account of seasonal variations and the times of day at which temperatures tend to be lowest and highest?

d) How many real people's experience is it appropriate to exclude via the theoretical approach: Is it normal to be in Finland in winter? Is it acceptable to (mathematically) exclude Madrid?

iii) What speeds and torques may reasonably be expected to be encountered in normal vehicle operation and use?

a) Does it include all of urban driving, commuting, long-distance driving, hurrying to get somewhere, driving at (or a little above) the speed limit on the motorway, accelerating away from traffic lights where lanes are narrowing, accelerating away from a rural roundabout or accelerating hard to overtake a convoy of lorries or join a road?

b) Does it include driving like the confident driver (for whom "performance" cars are designed, optimised and marketed, including some specific "Sport" or "Sport+" modes to increase acceleration)?

c) Is it normal to use full torque in relatively underpowered cars to keep up with the flow of traffic on major roads?

d) Does it include loading a car with passengers or goods (to go away for the weekend, or take a child to university), loading a van with equipment and goods, towing a trailer or caravan (with the towbar), loading up a roofbox or bikes on the roof, driving up and down hills?

e) What use can be made of the WLTP datasets?

The submissions in outline

408. The Claimants' approach is a broad one. They contend that the EU authorities and analogous provisions in other legislation, as well as the general aims and approach of the ER, strongly indicate (if not dictate) a conclusion that the "*reasonably expected*" provision means that the vehicles must achieve NEDC equivalent results in real world driving conditions such as may be encountered across the EU when the vehicle is being used in a non-abnormal way. This equates to:

i) The Claimants say that NDC is to be assessed over the whole of the EU rather than UK only. That is because (a) the ER, an EU instrument, is directed at the territory of the EU and (b) the CSV's all received type approval for use across the EU;

ii) "NDC" should be approached as two sub-questions. That is, when considering whether a condition falls within the provision, one must ask (a) whether the condition could reasonably have been expected to have been encountered while (b) the vehicle is subject to normal operation and use;

iii) NDC is not exhausted by those conditions found in the NEDC or the moderate or extended boundaries of the RDE test;

iv) There is no requirement for a condition to be "normal" (in the sense of "typical" or "common") for it to fall within the scope of Article 3(10). "Conditions" need only be reasonably expected. That includes, the Claimants submit, all conditions except for those which are truly "extreme" (i.e., those which it would not be reasonable to expect). What is covered is "*all conditions which some drivers anywhere in the EU could reasonably expect to encounter sometimes, even if they are uncommon/rare/unusual/atypical or for short periods, or only in one season of the year*";

v) A use will be "abnormal" where it is of such a type that "the regulators" cannot have required a properly functioning ECS during that use. The Claimants suggest that, essentially, normal consequently includes all fashions of driving except for those specifically outside the manufacturer's contemplation for that particular vehicle;

vi) The correct approach to the expert evidence is to look at ranges of conditions not based on averages. To do so would, to take the example of temperature, "blend out" the daily peaks and lows likely to be encountered during morning and evening rush hours;

409. Following this approach for the Claimants NDC consists of:

i) Ambient temperature: any temperature between -15°C and 40°C; thus, embracing temperatures in Finland in the winter or Madrid in the summer;

ii) Altitudes in higher parts of a number of EU states (France, Austria, Spain), as well as towing or laden conditions;

iii) On torque and speed, the manufacturer's stated maximum net torque and maximum engine speed are NDC.

410. There is, unsurprisingly, a considerable degree of overlap between the submissions of the Defendants. They contend:

i) First, that the territorial scope of Article 3(10) is either the UK, England & Wales, or Great Britain. That is because as much as the CSVs may have received EU-wide type approval, the core sample vehicles (by virtue of being right hand drive vehicles with miles as the default units on their odometers) were marketed, sold, and intended for use in the UK/England & Wales/Great Britain;

ii) Second, that Article 3(10) ought to be interpreted as imposing a requirement for "the conditions" to be "likely" or "typical"; naturally, this excludes atypical or abnormal conditions. And, as what is "likely" is what the court ought to be concerned with, the "range of normal" ought to be calculated by way of averages;

411. On the ranges the Defendants to some extent parted company, advocating as follows:

i) Ambient temperature:

a) Mercedes (ultimately supported by Ford, who were initially somewhat agnostic) contends for a Range of Normal no wider than: For the UK, 3ºC to 25ºC inclusive, and altitudes of 250m and below; For the EU, 0-3ºC to

30°C inclusive, and altitudes of 600m and below; Alternatively the original RDE Moderate approach: 3–30°C;

b) VW contends that the range of ambient temperatures for the EU+UK can be no greater than 0°C to 30°C (the later RDE Moderate range) and the upper threshold for altitude can be no more than 700m.

ii) Altitude: no higher than 700m, in the view of VW and PCD, or no higher than 600m, in the view of Mercedes, if the territorial scope is taken to be EU + UK. If the scope is taken only to be the UK, Mercedes argue the upper limit ought to be 250m, whilst PCD say 300m;

iii) Engine speed and torque: PCD argue in the first instance that the conditions found in the NEDC represent the limits of NDC. Mercedes argue that the court should take the 95th percentile of torque and speed based on the data provided by the expert witnesses.

412. Before moving on to the analysis I pause to place a marker that the complications involved in this stage of the process as illustrated by the expert evidence do feed into the question of whether this is the right approach to the overall questions of construction. If the correct construction of Articles 3(10) and 5(2) means that this approach is relevant, it follows that that means it is necessary to deconstruct in great detail the individual words of the Regulation and to seek expert evidence in more than one discipline to calibrate meaning of those words. There is scope for doubting whether an approach which involves such complexity is what was intended. This doubt or question can be revisited at a later stage of the analysis.

Analysis

Conclusions to "reasonably to be expected"

413. The Claimants place considerable weight on regulatory backdrop. I entirely accept the submissions which were made that this entire subject has to be viewed against the relevant regulatory backdrop for this set of regulations as outlined above.

414. I am less in sympathy with the Claimants' further regulatory submissions namely that their approach to "*reasonably expect to be encountered*" should be viewed through the prism of two factors.

415. The first is that when the European Parliament sought to amend the wording of Council Directive 70/220/EC, it had originally proposed the phrase "*under conditions typically arising in normal use of the vehicle*" but the drafters rejected this wording (without further published debate) and adopted the (wider) US definition, which was then adopted in UNECE Regulation 83. The drafters therefore rejected "*typically arising*" in favour of *"reasonably expect to be encountered"*. This, it is said, contradicts any case based on "*typically*".

416. The second is that their approach to construction is supported by the use of the phrase "*normal use*" elsewhere in emissions legislation: see (i) UNECE Regulation 83 reg 4.10.3 and Annex 11 para 3.2 providing that the OBD diagnostic system must comply with the requirements of the Regulation *"during conditions of normal use"*; and (ii) reg 5.1.1

providing that emissions components must be designed to enable the vehicle to comply with the Regulation *"in normal use"*, "*despite the vibration to which they may be subjected*". The Claimants say that this plainly does not mean that diagnostics and components must only operate in the narrow conditions identified by the manufacturers.

417. Although the basis for these arguments can easily be discerned, I do not accept that they lead to the Claimants' preferred conclusion.

418. As to the first point, there is a difference between "typically" (equating to "*more often than not*", or "*much more often than not*") and something more generous than the manifestly abnormal. The drafters are dealing with slippery concepts. All that can definitely be taken from this is that a very narrow window was not being aimed at. That does not mean that the intent was a very wide one.

419. As to the second point, this is an apples and oranges comparison. With OBD and diagnostics the focus is the durability and failure of components. This is very different to dealing with performance issues.

420. Nor do I accept that the case law much assists the Claimants. The principal CJEU decision on NDC is *GSMB Invest* (which is non-binding). The Defendants pray in aid the fact that the CJEU referred at [40] to "*real driving conditions, such as are usually present in the territory of the European Union (see to that effect [CLCV] paragraphs 96 and 101)"*. The Claimants argue that this does not support the view that the NDC must be typical contending that:

    i) The point being made in [40] is that the conditions go beyond NEDC conditions, which is what those paragraphs of *CLCV* say, and what the CJEU goes on to explain and repeat in [41]-[42];

    ii) The phrase "such as" means here "for example";

    iii) The CJEU then went on at [44] to say that it was "*common ground that ambient temperatures below 15°C and driving on roads at altitude above 1,000 metres are considered as normal within the territory of the European Union*" referring to boundaries in the VW device, and then went on at [45] to cite as support for this view the fact that the ER lays down a cold start test at -7°C;

    iv) It is therefore clear that the CJEU is not taking the view that conditions must be typical, but rather conditions that appear, extreme conditions aside, anywhere in the EU.

421. As for the last point this does not follow. With a classic CRDD in the frame (see above), the issue was not properly in focus in *GSMB Invest* (as is apparent from the concession as to the range of normal). Further the concession may well, as Ford submitted, have been influenced by the fact that all the parties to that litigation were Austrian (and therefore more likely to regard 1,000m as perfectly normal). In my judgment there is little on this point to be extracted from *GSMB Invest* – save possibly this: that the CJEU did not analyse by reference to abnormality or "*all in except*". In summarising for the purposes of a point which was not central, the instinctive flight was to a real/usual concept. This is, for what little it is worth, nearer to the Defendants' case.

422. The Claimants have also attempted to use (albeit as a "sense check") the Defendants' own contemporaneous approaches as relevant material. It hardly needs to be said that this is not a permissible approach: such material is probably not admissible and in my judgment it is not relevant. I therefore simply note that many of the Defendants took a broader approach than they are now advocating for. Thus from 2011, Mercedes made clear to third party contractors like IAV what Mercedes' own off cycle boundary condition requirements for the EU were: -7°C to 40°C with an altitude up to approximately 2,000 m. By 2017, these conditions had extended further to -25°C to 40°C and at least 4,000 m. And in 2016, Ford's internal guidance settled on -10°C (AAT)/ (-15°C ECT) to 38°C and 0 to 1,500m as the "*Minimum Range of "Normal" Operating Conditions*". But these are manufacturers considering not just emissions but also the requirements for the (different) question of OBD; and they are manufacturers in the midst of a planned move to more strict emissions and other limits planning with margins in mind. They are often also documents which date from considerably after the "*design freeze*" cut-off date for these vehicles.

423. Thus the question of what is "*reasonably to be expected*" cannot be determined by reference to any external source or material. However, bearing in mind both the wording and what it then imports in terms of practical performance, and the implications of a broad reading against the background of the gradual imposition of emissions limits, I consider that it is clear that the Claimants' approach to this cannot be correct.

424. As to the wording, while it is true, as the Claimants say, that the drafters included no requirement that conditions which "bite" (i.e. are to be taken to be NDC) are encountered "*normally*" or "*regularly*", or "*typically*" or for a "*a substantial period*" of normal vehicle use, so also is it true that the drafters did not define their concept by excluding the abnormal. Given that that is potentially an easier concept to capture (*pace* some of the refinements to be considered below), that might well be taken as an indication that the drafters were aiming at capturing the core of driving conditions, not the pool, excluding a few outliers.

425. Looking simply at the words the inclusion of the word "*expectation*" rather than solely "*encountered*" seems to suggest a probability aspect. While the drafters moved away from "*typically*" there is no record that they intended a substantial change of meaning from that word; it feels more as if they were trying to draft out obvious issues with that word ("*Typical*" – more likely than not? Or even more likely than that?). The CJEU's instinct is here interesting and coheres with this approach. In reaching for "*usual*" the CJEU has approximated to typically, and not to anything very far from it.

426. Then in practical terms, the broad "*everything but abnormal"* approach in partnership with the Claimants' pleaded approach to RIE means that a manufacturer either is or risks being in breach of the ER if emissions limits are not met, way outside the parameters of the NEDC. Whereas the approach by reference to "*routinely*" and "*regularly*" and "*commonly*" makes sense of applying in real world conditions which are not captured by the (obviously imperfect) NEDC, but without placing an impossible burden on the manufacturers as limits were introduced and technologies developed.

427. I therefore conclude that the correct interpretation of "*reasonably be expected to be encountered*" involves a consideration only of conditions which are common, or regularly or routinely seen. That of course still begs the question of what is common or regular and how one uses the material.

The RDE

428. Before passing on to the individual conditions, some further mention requires to be made of the RDE test parameters. Although everyone accepts that they post-date the relevant iteration of the ER and construction via them is therefore not permissible, everyone equally agrees that they must be see as a sense check

429. For the Claimants "*the RDE parameters should not be treated as exhaustive, but their inclusion is persuasive as to such conditions being NDC because, although they post-date the ER, as Mercedes says, they constitute a "considered, evidence-based approach which was adopted by EU legislation*"".

430. The Defendants' approach, which I prefer, is to use the RDE in its initial iteration as a sense check, bearing in mind that it would be surprising if the legislative intention for the first iteration of the ER was to cover more than was covered by the RDE which came into force later. I have in mind here *inter alia* recitals (6) and (7) which refer to transitioning towards "ambitious" limit values at the Euro 6 stage, the review planned at the four year stage at (9), (12) which posits future stricter emissions limits, (15) putting down a marker as to a more close nexus between type approval and real world.

431. Overall therefore the answer to which one might come on this if the question arose shorn of context might well be rather different to that towards which the context steers. In my judgment one cannot divorce this question from the context given by the regulations. The wording was arrived at in that context. And while, technically, it must be right that the later debates over the content of the RDE test are not admissible to construe the meaning which applies to the time of the NEDC test, the fact of those debates echoes the context which predates the regulation. The experts were agreed on this: regulatory and expert considerations of "normal" (such as in the design of the RDE test) aimed at a compromise between (i) the aims of improving air quality and (ii) technological and commercial viability. This reflects the practical context in which the definition operates; the meaning of NDC is the basis of a standard that manufacturers have to meet to obtain TA. That standard needs to be set with commercial practicalities in mind, as the ER and its *travaux* make clear.

    In other words, at this point everybody knew that this regulatory scheme was a first step. Everybody knew it presented challenges. Everybody anticipated further developments as the years (and technology) progressed. Against that background the Claimants' attempts to suggest that in temperature terms the intention was to capture the same window as (or a bigger window than) the later RDE test is doomed to failure.

Territorial scope

432. The question arises of whether the appropriate territorial scope for NDC is the EU or the UK.

433. The Claimants contend for the EU. The Defendants contend not, with the scope advocated for varying between the UK or GB (excluding NI) or England and Wales.

434. Ultimately I am not persuaded by the Defendants' arguments.

435. The starting point is that the EU CRF was a pan-EU harmonising regime that deliberately led to a single TA valid across the EU, to allow free movement of vehicles as goods and for travel. Any vehicle could, pre-Brexit, reasonably be expected to travel anywhere in the EU. Has Brexit changed this?

436. While the temptation to say that it must have done so is obvious, the reasons why are harder to find. Some Defendants say that the cars were "marketed for sale" in the [UK/GB etc.]. Others rely on the left hand drive nature of the vehicles. These are not good points:

i) The ER makes no distinction between right-hand and left-hand drive as a technical requirement for ETA. The ETA, which is what approves the ECS, is issued without consideration of left- or right-hand drive, or whether instruments are marked in metric or imperial speeds, and nowhere mentions these points. The same ETA can be found in whole vehicle type approvals for left-hand drive vehicles sold in the GB, Northern Ireland, Ireland, Malta and Cyprus, and in right-hand drive vehicles sold in the rest of the EU;

ii) The Speedometer TA is regulated by Regulation 661/2009 and UNECE Regulation 39. Articles 5.1.2 and 5.1.4 of the latter require vehicles with imperial units to also display km/h markings, because this is necessary to ensure harmonised trade across the EU;

iii) To obtain WVTA, all relevant separate system TAs (braking, speedometer, seats, seatbelts, emissions, etc. as set out in Annex II of the FR must be obtained: see [70] of the *KBA Judgment*. The template form for a WVTA does allow for a vehicle to be approved (at this later stage, after ETA has been granted) as left or right-hand drive, but all the CSVs were granted WVTA for both. The WVTA is therefore also granted, partly on the basis of passing emissions tests, across all of the EU's left- and right-hand drive territories.

iv) The CoC – a document that is not part of the TA process and is obtained after WVTA is granted – does specify that permanent registration is dictated by the right- or left-hand drive, stating the CSV "*can be permanently registered in Member States having left hand traffic and using Imperial units of measurement"*. But even then, the vehicle can (reasonably be expected to) be driven across the EU, which is legally permitted and common (e.g. car ferries from Dover and Eurotunnel LeShuttle from Folkestone);

v) The Defendants' interpretation would be entirely contrary to the aims of the ER and the TA process. All CSVs obtained ETA, WVTA and CoCs whilst the UK was part of the EU and thus obtained TA in compliance with the ER (as pre-IPCD EU law). The ER Recitals are clear as to its objectives to provide harmonised trade to avoid differing requirements in one Member State from another (Recital 27).

vi) The CJEU jurisprudence in 2014 on right-hand drive vehicles affirms the Claimants' approach. CJEU case law confirms that in an internal market with the right to free movement, the FD and Steering Wheel Directive 70/311 would have taken account of the fact that some Member States drive on the left when establishing their harmonisation objectives. It therefore was unlawful for Poland and Lithuania to impose restrictions prohibiting the re-registration of right-hand drive vehicles (bought in the UK and Ireland): see Judgment of 20 March 2014

Commission v Republic of Poland EU:C:2014:173 and Judgment of 20 March 2014 *Commission v Republic Lithuania* EU:C:2014:172.

437. Brexit changes nothing for the vast majority of the Claimants' vehicles because they were designed, manufactured, granted TA, imported and sold long before Brexit. The great majority of causes of action in this trial accrued pre-Brexit under the pre-Brexit ER, and IPCD did not retrospectively affect these causes of action.

438. Interestingly there is not a single piece of contemporaneous evidence to support the suggestion that any of the OEMs treated left and right hand drive vehicles, or dual speedometer and km/h only speedometer vehicles, differently when it came to Art 3(10). All had the same calibrations.

Temperature

439. The parties, via their climatology experts, deployed a range of very detailed and very interesting evidence. The experts analysed a range of datasets (with a good level of agreement as to the relevance and utility of those datasets). They provide averages across the year, for each season, and monthly, and daily. They provide analyses of the maximum and minimum daily temperatures per country; and also the number of days per year, season and month when a certain temperature is reached (i) at all, (ii) for the whole day.

440. They also considered questions of where when and why people (statistically speaking) drive. So as Ms Donnelly KC put in in cross examination (agreed by Professor Mills) "*we're concerned with intake temperature, the reason we're concerned with when people are driving by reference to temperature is if there is a very cold temperature at 3 or 4.00 in the morning and the roads are deserted, that's going to mean that very few drivers are actually going to experience that temperature?*".

441. The result of this exercise was a large measure of agreement. So the experts were agreed:

    i) Normal driving conditions as a concept needs to account for variations in where people live and when they drive;

    ii) Averaging is a good place to start as it is a good way of including and summarising data, and they agree that weighting improves that summary;

    iii) Averaging has issues in that it reduces visibility of variance by smoothing it out. The average figure is not the condition experienced the majority of the time or even much of the time, it is merely the weighted centre of the condition experienced. Thus the daily average makes invisible the daily range (several degrees) due to the diurnal cycle of night and day;

    iv) Increased visibility of detail and granularity helps, including (i) across the EU, (ii) within countries, (iii) across the 12 months of the year, and (iv) across the day and night (or at least the hours in which driving takes place). Professors Chapman and Mills both looked at all of these, with Professor Mills analysing temperature based on exactly where each EU inhabitant lived (to within a 1km square) and calculating the number of people encountering particular temperature thresholds. This allowed analysis of how many people experienced each temperature how many days per

year, including across state lines (since temperature is no respecter of political borders);

v) Population data is the best proxy available for estimating car use;

vi) If there is going to be averaging, population weighted averaging is preferable (as Ms Donnelly KC put it, the *"average temperatures for Swedes"* rather than the "*average temperatures for Sweden*"), but geographic averaging necessarily obscures the variability of temperatures across the EU including within each country (Scotland is much colder than Cornwall; southern France is much hotter than northern France);

vii) Both Professors Chapman and Mills thought it preferable to descend to the detail of individual countries, and indeed consider the variability within countries to some extent. This led to a number of charming graphics like the following:

4.24 **Table 10:** Single-day minimum temperatures (Temperatures in °C).

Country	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Austria	-19.77	-20.23	-20.1	-10.05	-1.85	1.69	4.39	3.2	-2.1	-11.93	-15.09	-21.9
Belgium	-14.71	-13.99	-10.4	-3.97	0.35	2.6	6.67	6.31	2.17	-4.23	-9.08	-13.15
Bulgaria	-17.85	-18.9	-14.8	-6.11	2.18	6.54	9.71	9.34	2.19	-5.11	-11.61	-18.49
Croatia	-15.23	-15.98	-13.42	-2.89	3.28	6.27	10.16	8.21	4.08	-2.58	-7.65	-15.46
Cyprus	2.21	1.5	4.04	5.36	11.73	12.85	19.05	20.7	16.14	10.28	5.87	2.77
Czech Republic	-19.9	-20.57	-15.14	-6.68	-1.84	3.12	6	5.5	-0.23	-6.3	-12.33	-23.03
Denmark	-13.41	-13.41	-11.03	-3.46	0.78	4.16	7.89	7.97	4.05	-3.48	-6.23	-12.24
Estonia	-29.32	-31.08	-20.32	-9.97	-4.39	2.48	5.98	5.07	-1.72	-11.07	-17.85	-23.88
Finland	-35.35	-32.17	-25.05	-16.85	-7.17	0.3	4.23	1.76	-4.21	-18.02	-23.13	-30.36
France	-9.24	-12.4	-10.71	-2.34	0.75	4.59	7.94	7.04	3.76	-2.71	-7.72	-10.02
Germany	-17.41	-18.52	-12.97	-5.81	-0.39	3.36	7.21	5.63	2.36	-5.12	-9.6	-17.07
Greece	-8.08	-8.76	-3.72	-2.84	6.51	9.99	13.38	14.62	9.35	3.77	-2.41	-9.41
Hungary	-18.1	-18.61	-14.86	-4.6	1.52	5.59	8.87	8.4	2.35	-7.31	-11.56	-18.2
Ireland	-6.85	-4.25	-5.27	-2.46	0.39	3.29	6.94	5.23	2.32	-1.57	-4.81	-10.09
Italy	-7.18	-9.15	-8.18	-3.21	3.6	7.67	11.06	10.43	6.85	1.8	-3.33	-8.05
Latvia	-29.52	-29.88	-22.19	-9.16	-3.52	2.32	5.77	4.66	-2.29	-9.21	-18.62	-25.51
Lithuania	-28.23	-29.78	-22.11	-9.34	-2.95	2.43	5.79	5.14	-3.27	-6.95	-18.53	-27.38
Luxembourg	-15.85	-15.19	-16.05	-5.31	-0.26	1.27	5.95	4.99	2.01	-4.52	-11.36	-15.42
Malta	7.73	7.25	8.17	9.63	13.85	16.81	20.32	21.26	19.65	14.51	11.25	6.88
Netherlands	-14.88	-13.81	-13.51	-3.68	1.15	4.02	8.02	7.15	3.6	-3.64	-7.32	-11.8
Poland	-26.26	-23.88	-16.34	-6.05	-2.29	3.44	7.13	6.17	0.13	-5.49	-14.36	-22.34
Portugal	-2.37	-1.43	-1.63	2.61	4.43	8.37	10.65	11.61	7.93	4.45	1.1	-1.47
Romania	-21.25	-22.04	-16.07	-5.09	0.46	6	8.08	7.52	0.37	-6.81	-15.14	-19.48
Slovak Republic	-22.61	-20.86	-15.51	-6.06	-2.63	4.23	5.93	5.16	-0.42	-7.33	-12.27	-21.86
Slovenia	-18.62	-16.55	-18.48	-4.38	1.12	4.66	7.55	5.13	1.68	-5.73	-10.71	-20.5
Spain	-5.47	-5.1	-5.25	0.65	2.53	7.43	10.4	10.23	6.43	1.85	-2.82	-5.95
Sweden	-28.32	-27.2	-23.04	-12.36	-6.3	1.42	4.64	1.64	-2.36	-15.13	-19.54	-25.03
United Kingdom	-7.67	-7.07	-5.86	-2.5	0.55	2.82	6.81	5.96	3.43	-1.24	-5.89	-10.11

viii) Commuter travelling peaks generally align in broad terms with daily maximum and minimum temperatures albeit with seasonal variations (alignment being closer in December than June) and with most journeys (in absolute terms) taking place after the daily minimum temperature; and equally most journeys taking place below the daily maximum temperature;

ix) The approach of Professor Pope for Vauxhall (the charmingly named "*modified Malfettani approach*") takes a single monthly average across the EU (e.g., in January, 3.26°C). The analysis is therefore one in which you (as Professor Chapman put it) "lose" geographic variability (by summarising within a single weighted figure). This has some potential to address some of the fundamental

issues regarding where and when people drive, while bringing with it its own issues, not least that its upper limit is within the range used in NEDC, thereby suggesting that NDC stops before the end of the NEDC range, which no-one suggested;

x) Only a minority of EU countries have any season in which the average minimum temperature is below zero. As Professor Mills accepted "*We can say that for most people in the European Union, if they are driving, the temperature is likely to be above 0*";

xi) Only one country in the EU has an average maximum in any season is above 27ºC and only 2 above 30ºC in the hottest part of the day. Thus typical and usual driving conditions in the EU are not, even in summer or July, the hottest month of the summer, over 30ºC.

442. It was also agreed that all of the expert approaches had limitations. As Professor Chapman said:

> "Unfortunately, …., we just do not have the position where we've got the data that we need to give you a definitive answer to this question. And every approach that we've looked at today, including myself's, Professor Pope's Professor Mills' we've got limitations and compromises that we're all very open about and so therefore we do know what we're giving you is a best first guess at where we are, often with caveats, other things to consider"

443. As Ford put it tellingly in closing:

> "The evidence of Professor Chapman and Professor Mills, while insightful, highlighted just how unrealistic it is to seek to find a single clear basis for determining the precise climatic etc. boundaries of NDC by reference to meteorological, traffic, and geographical evidence. The experts agreed that no standard methodology exists to answer the questions posed... While both experts agreed that their evidence was complementary of the others, and data sources used were generally valid, neither expert was in possession of the actual driving data that they needed to give a "definitive answer" to the question ... The existence of multiple valid approaches cannot provide an acceptable level of legal certainty."

444. In other words: if this exhaustive review of the data tells you that you don't have the data, the Court must wonder whether this is the right question.

445. However, since the exercise has to be performed it was helpful that a limited number of material differences emerged. Thus the experts (accepting a degree of utility in each other's approach) diverged on whether it was overall best to focus on population (in absolute and percentages) that will be exposed (in terms of days) to different minimum and maximum temperature or to apply a population weighting to temperature, reporting modified average temperatures and at two temperature time-slices aligned with peak driving.

446. The Claimants' original case was that averaging is entirely misguided, since (as the experts agree) it blends out the daily peaks and lows of temperatures that are encountered

at evening and morning rush hour, i.e. clearly reasonably expected to be encountered. However contrary to the Claimants' case Professors Chapman and Mills were broadly in agreement that temporal averages are a good starting point of what constitute "normal" temperatures. They also agreed that averages should be accompanied by some measure of reasonable variations, because each average carried its own limitations. Thus an average minimum figure for a particular country gives a faulty impression because (i) local conditions may be outside the EU overall norm and that country may be small in population terms (ii) minimum temperatures are almost always occurring before commuting peaks and (iii) overall most driving happens after the daily minimum figure. And so, Professor Mills states that "*diurnal maximum and minimum is an imprecise indicator of the ambient temperature conditions when people drive*".

447. Professor Chapman's view was therefore that since the vast majority of driving on any given day will happen at times of the day away from the occurrence of minimum and maximum temperatures, average temperatures are more representative of the broader conditions encountered by drivers. At the same time driving peaks are if not in approximate alignment with maximum and minimum temperatures, not very far off them at most times of year.

448. Another source of information was material explaining days of exposure of temperatures below a defined threshold, but this was treated with some caution by both experts because "*[a] day is counted if the minimum temperature falls below the threshold at any point…" and "without traffic data, it is impossible to fully understand how much driving actually goes on below a threshold*".

449. The Claimants also relied upon what they said was a "growing consensus" in the EU cases that a temperature range of -15°C to 40°C is NDC.

450. The lower limit derives from Annex XVI Section10 IR, as now taken up in the RDE requirements, for full reagent functionality at low ambient temperatures, including a parking period of up to 7 days at -15 °C. The Claimants asked: "*Why would the IR and then the RDE require each vehicle to be tested as to the effects of parking at -15°C for 7 days on freezing the reagents etc, if that was not a temperature that was NDC*?"

451. The Claimants also point out that there is something approaching a developing consensus in other courts:

    i) The RDE parking requirement of -15 °C was taken up by the Administrative Court of Schleswig-Holstein (first instance) on 20.2.23 at [275] to [279], noting that this is "*periodically… regularly exceeded*" (in the case of this lower limit, this means it is regularly colder than this) in Finland, Estonia and Sweden;

    ii) The upper limit derives from the RDE maximum of 35 °C, and the fact that this was "*regularly exceeded*" in Greece, Portugal and Spain in the summer months (see the same decision of the Schleswig-Holstein court);

    iii) This -15°C to 40°C range was applied by the Stuttgart OLG (penultimate appeal court) a number of times, including finding therefore that a Mercedes B-class 200 CDI Euro 5 with OM651 engine had a thermal window ending at -10°C post-update which was a PDD, as was 0°C. Mercedes' window of -60°C to 55°C, however, was lawful;

iv) The Karlsruhe OLG on 25.9.24 at [140] held that even >40°C is still NDC because it is "*still common in the entire Union area" "especially in the southern European summer, especially over an unshaded road*";

v) A substantial number of other German courts have also ruled that 0°C is too high to cover all cold NDC, and that 32/33°C are too low to cover all hot NDC.

452. I do not however regard this supposedly developing jurisprudence as of any assistance. None of the case are binding and none seem to have involved anything like the detailed evidential enquiry which was undertaken in this case.

453. Nor do I consider it at all useful to have regard to the fact that Mercedes in a substantial internal investigation through the Normal Operating Conditions Working Group in 2017, settled on a temperature range of -14°C to 36°C for NDC. This was laid against the ranges required in the tests of various markets around the world (including Euro 6 RDE steps 1 and 2), and Mercedes noted that "*when averaging the requirement, one obtains a good agreement between the legal requirements and the historical meteorological data*". For one thing, as the Claimants accepted, this was an exercise which was assessed worldwide rather than EU-only – it was apparently based on an assessment of maximum and minimum daily temperatures in 522 regions, covering 98% of metropolitan regions, population weighted (i.e. deserts and the polar regions would not have affected these figures). For another it was not an exercise in any way aimed at the particular provisions in focus here. And as has already been considered "normal" may mean different things in different contexts.

Conclusions

454. The answer here must be rooted firmly in the excellent expert evidence with guidance given by the context and the conclusions as to the meaning of "*reasonably to be expected*". One aspect of the expert evidence I have not adopted is the experts' preference for national rather than EU wide data. It is simply not feasible to process the questions involved via the amount of data which that involves. However, I do consider that it is a useful test or check to the analysis to look at what the EU wide percentages mean in terms of notional geographical exclusion.

455. Here we can take the following facts as proved:

456. The highest and lowest values for the day are of no utility: not all experienced temperatures are normal and analysis is best not done by reference to extremes and outliers;

i) The experts agreed that the coldest temperature occurs shortly before sunrise, and the warmest occurs in mid-to-late afternoon. The experts also agreed that a temperature close to the coldest temperature is present for some hours before sunrise (there is some cooling throughout the night but most of that is as the sun sets, so the temperature is close to the minimum for the whole night).

ii) Commuter peaks are the busiest times, though they are obviously not the times when all people drive, or even (possibly) most people drive. There is some alignment between these times and daily minima and maxima:

a) The minimum in winter is encountered shortly before (or on occasion at) the morning commuter peak, and the maximum in summer is encountered during the afternoon and close to the commuter peak;

b) The alignment is thus imperfect at best. Further the minimum in summer occurs hours before commuter peaks and the winter maximum also occurs before rush hour (though these data points are less relevant for this exercise);

c) On average I conclude that vehicles can reasonably expect to encounter something close to the minimum and maximum temperatures.

iii) Looking at national averages:

a) Lapland has an average winter minimum temperature of -15°C (and a population density of 2 people per km);

b) Average, unweighted monthly daily minimum temperatures can be found close to -15°C in Finland and Sweden in January and February, though Professor Chapman's figures suggested that the average figures were closer to -10°C and -8°C respectively;

c) Only Finland has a population weighted average temperature below -5°C. That is also the result produced by the "*modified Malfettani*" approach;

d) Average daily minimum temperatures in January to March for much of the rest of the EU is closer to low single figures (positive). The population weighted figures are not strikingly different;

iv) At the same time it might be said that a large number of people (82.6m) in Germany, France, UK, Italy and Spain will experience 1 to 5 days of -7°C (12.4m in the UK) and almost 134m people in the EU will experience this ambient temperature for 6 to 20 days every year.

v) As to low temperatures "experienced" (at some point during the day);

a) 95% of the EU and 99.3% of the UK experienced below 5°C for more than 35 days;

b) More than 85% of the EU and 98% of the UK experienced 3°C or below for more than 35 days;

c) Moving to below 0°C: 70% of the EU experienced that for more than 35 days, almost 60% of the UK did as well.

vi) For average high temperatures there is very little relevant material, save to say that very few countries experience any months with average temperature over 25°C and only Cyprus has an average daily maximum of over 30°C in summer (unweighted). Allowing for population weighting Greece also has a July average temperature of over 30°C;

vii) As to high temperatures similarly "experienced":

a) In the UK, over 24 million people or 40% of the UK experienced 1 to 5 days of over 30°C;

b) 43% (or 207 million people) of the EU (and 87% of Germans) experience temperatures over 33°C for 1 to 5 days every year;

c) 32% of the EU experienced temperatures over 35°C for 1 to 5 days. Nearly 5 million people in Spain experience more than 35 days of over 35°C.

457. **I conclude that the temperature window which was seen as Normal Driving Conditions for the purpose of the NEDC test era (and hence for the vehicles in issue in this case) was 3°C to 30°C. It follows that alleged Thermal Windows PDDs outside this ambit would not be PDDs**.

458. I should perhaps add that this obviously coincides with the RDE moderate limits which were the first RDE limits imposed. However further support for this approach is gained from the fact that as was pointed out in closing citing a Q&A document provided to EMIS by Dr Paul Greening of the ACEA (the European Automobile Manufacturers Association):

i) RDE was designed around an analysis of published traffic statistics for the EU27 by an independent consultancy;

ii) It was designed to cover 92% of real driving conditions with other conditions being described as "outliers";

iii) The Commission took into account data which suggested that 97% of EU27 driving is 0-30°C and 98.7% below 800 metres?

459. Further in the ER the Type 6 petrol low temperature test permits 15 times the amount of CO and 18 times more hydrocarbons at the -7°C level.

Altitude

460. A variety of different approaches were endeavoured here to give meaning to vast datasets which struggled to be meaningful.

461. A very useful summary is provided by Professor Chapman's table 43:

Table 43: Percentage of the EU+UK population residing in NUTS L3 regions above certain height.

Altitude (m)	% Population above	% Population below	Number of NUTS L3 regions
2100	0.00%	100.00%	None
2000	0.05%	99.95%	Italy (1 - Aosta Valley (2098)) Austria (1 - Tiroler Oberland (2084))
1900	0.05%	99.95%	Austria (2), Italy (1)
1800	0.09%	99.91%	Austria (2), Italy (2)
1700	0.26%	99.74%	Austria (3), Italy (3)
1600	0.29%	99.71%	Austria (4), Italy (3), France (1)
1500	0.45%	99.55%	Austria (8), Italy (3), France (2)
1400	0.56%	99.44%	Austria (8), Italy (4), France (2)
1300	0.70%	99.30%	Austria (10), Italy (6), France (2)
1200	0.74%	99.26%	Austria (10), Italy (6), France (2)
1100	1.09%	98.91%	Austria (11), Italy (7), France (4), Bulgaria (1), Germany (1), Spain (1)
1000	2.27%	97.73%	Austria (12), Italy (8), France (7), Bulgaria (2), Germany (2), Spain (6), Greece (2)
900	2.98%	97.02%	
800	5.52%	94.48%	
700	7.81%	92.19%	
600	10.73%	89.27%	
500	18.51%	81.49%	
400	24.60%	75.40%	

462. Having used that summary it is right to note that the experts agreed that the highest resolution data is that used by Professor Mills, and that Professor Chapman's method likely overestimates populations living at high altitudes.

463. Both in terms of population residence and road length a small percentage of driving is likely to take place below 1000m or even 700m altitude.

464. It demonstrates that:

i) At best 97.7% of the EU lives below 1000m (Mills: 99.45%), and a very small percentage of driving happens at this altitude;

ii) Applying a 600m cut off means 6.835% (Mills) or 10.27% (Chapman) of EU population is excluded from NDC. Professor Mills' evidence adds that some 13% or over 27,406 kms of EU highways and primary roads are above 600m;

iii) Applying a 700m cut off means 3.75% (Mills) or 7.81% (Chapman) of the EU are excluded and Professor Mills adds that 10% or 20,008 km are above 700m.

465. This is a question where the Gordian knot has to be cut. The target as I have decided is not "everything but abnormal"; it is common, regularly to be encountered. If the evidence rested on Professor Chapman's analysis, I would probably consider that 700m was the right figure. However the agreement of Professor Chapman to the higher resolution of Professor Mills' data and the results produced by it is significant. Excluding over 10% of the population would seem close to the margins taken by itself. But if as Professor Mills' evidence suggests the true figure is less – somewhere closer to 6-7% that makes a difference. **The expert evidence accordingly supports a Range of Normal for the EU which stops at atmospheric pressures of around 945 hPa (there was some divergence between the parties as to the metre equivalent – but around 600m)**.

466. If contrary to my conclusion above the answer had to be geared to the UK only the evidence that 20% of Scottish road kms, 16% of Welsh are located at altitudes above 300m, and 44% of Scottish road kms and 43% of Welsh are above 200m indicates that the line would be drawn at altitudes of 250m (atmospheric pressures of around 980 hPa and below).

Torque/Speed/Gear

467. There is no extant CJEU authority which delves into the issue of normal by reference to these criteria, and this part of the case gave rise to a huge range of expert and factual evidence. Not all of this was highly relevant as the picture which developed of the way the engines worked demonstrated that calibrations relating to torque and speed were rarely simplistic, such that one could read across conclusions as to normal ranges of torque and speed. Often torque and speed modulations intersected with other aspects of EGR calibration, such as MAFSP.

468. However the evidence still forms the backdrop to the granular issues and at points discrete issues of torque and speed do emerge; thus at least a short summary of the issues and some conclusions are necessary.

469. It is unfortunate that the evidence in this area was not perfectly helpful. Professor Hausberger's report was wider than the pleaded issues with the result that he came up with an overall approach to the limits of NDC, but did not deal with what torques or engine speeds would not be reasonably encountered in NDC. And while I appreciate the point that from a legislative design point of view a statistical analysis may be important to stress test subjective judgments, it is not a particularly good fit for this exercise. That problem was exacerbated by the fact that Professor Hausberger was candid that a range of views are possible and that any threshold between 70% and 95% would be reasonable to adopt as the boundary for normal driving, when he had adopted 95% in his report.

470. Dr Tate for his part had not really grappled with the NDC questions doing instead a rather different (if interesting) exercise via WLTP data and vehicles from within that data which he identified as proxies for the Mercedes CSVs. Perhaps as a result of the combined complexity of the exercise and the shortness of time (Dr Tate was a late entrant to the litigation) his report also featured a significant number of errors including double counting load factor, misidentifying proxies (Dr Tate compared Mercedes E and C class vehicles with a VW Golf and Kia Carnival people carrier) and using unhelpful benchmarking data skewed to urban driving.

471. The Defendants' position in summary was that Professor Hausberger's approach was to be preferred as more intellectually robust. The Claimants contended that there are no engine speeds or torques that are not NDC and that Professor Hausberger's 95% approach excluded some normal driving.

472. The Claimants' approach is, in my judgment, too grounded in semantic analysis and too little in practicality and common sense. It proceeds on the basis that "normal" used as a proxy for "*reasonably expected...*" can be calibrated in a binary way by excluding what is certainly abnormal. This results in a case which effectively says that only manners of driving which, in effect, involve using the vehicle in ways that it was manifestly not designed for (e.g., driving a vehicle not designed for off-road use off the road) or are manifestly irresponsible (the "boy racer" paradigm to which a certain amount of reference was made) can count as "not normal". The Claimants would say that provided a vehicle is physically capable of doing something and the manufacturer has not (expressly or impliedly) excluded that manner of driving from the range of legitimate uses, then that mode of vehicle operation and use is "normal". Of course it would not be normal to race a Ford Transit around Silverstone. But of course equally it is not normal to drive at 80mph in a 20mph zone.

473. One problem with the Claimants' approach is that it understates what is not normal: it is possible to use something in a way that is not normal even though it is broadly speaking being used in a way that was intended by the manufacturer. Thus in a manual transmission vehicle, it is eminently "normal" operation and use for the driver to select a low gear during periods of acceleration, for instance when joining a motorway from a slip road. That does not mean that whatever engine speed profile is produced can therefore be said to be "normal" for all purposes. Driving at top revolutions in second gear on the motorway would be far from normal. Burning rubber coming away from the lights likewise. But that has nothing, directly at least, to do with what the manufacturer did or did not intend. It is not normal because it would be an extremely unusual way of driving that type of vehicle.

474. By the same token, it would not be normal to drive a Ford Transit carrying its maximum recommended load, at a very high engine speed, for a very long period of time. Each element in isolation might well be "normal", and each, again in isolation, would have been within the contemplation of the manufacturer as ways someone might legitimately choose to drive. It is their combination that is unusual and correlatively not normal.

475. This engages the question of the different types of driving for which, under Euro 5 and Euro 6, the NEDC stood as a form of proxy. The Claimants' approach is likewise to try to find an overarching normality for all of these types of driving. But to do so by saying that everything which is not absolutely abnormal is "*reasonably to be expected in normal vehicle operation and use*" is, in my judgment wrong. If an overarching solution dubbed NDC is to be found, it has to be one which excludes driving which is normal in isolated uncommon conditions, but not normal in "vanilla" driving. It should also offer some margin, because normal and abnormal are not, in my judgment, binary concepts covering the whole spectrum of driving. This is a conclusion which chimes with the Tate/Hausberger evidence where Professor Hausberger agreed that there was a degree of artificiality in picking on the 95th percentile, and that anywhere between the 70th and 97th percentile might be chosen. It also resonates with the way Mr Kramer KC in questioning sometimes went beyond the simple normal/abnormal dichotomy theoretically at the heart of the Claimants' case to posit the "way beyond crazy driver".

476. On this basis it would actually seem likely that Professor Hausberger's approach is too conservative, rather than not conservative enough. That however was not argued, and his rationale for plumping for the 95% figure was a credible one. He said that a 70% threshold would be based on the amount of driving situations where drivers could drive as they want, without being hindered by traffic and that in his view this is not as relevant for emissions control because air quality is significantly impacted by high traffic volumes. Only 25%–30% of drivers can potentially drive as they wished (on open roads – largely driving outside of cities or at night time) with consequential low impact on air quality.

477. It follows that Professor Hausberger's choice of the 95% percentile probably is to some extent a conservative threshold in terms of impact on air quality, because it includes a portion of the 25%–30% of drivers who have a limited air quality impact. However it is conservative for a good analytical reason, and to diverge from it would be irrational, particularly when this portion of his evidence was not challenged. I accept that some limited support for this approach is to be gained from the fact that in developing the RDE Regulation the Commission expert group for NDC considered the 95th percentile to be a reasonable approach to certain parameters in the absence of scientifically agreed values, though many ultimately were not defined by that approach due to *"alternative needs for emissions testing"*. Further minimum RPA and v*a_pos95 calculations do use 95th percentile analyses in the RDE test. Further the upper limit of RPA was originally to be based on the 95th percentile but was not introduced because it was seen to be duplicative of v*a_pos.

478. The cross examination of Professor Hausberger focussed on hypothetical trips, designed to prompt a subjective view inconsistent with Professor Hausberger's analysis. Interesting (and often amusing) as this was, it did not convince.

479. Coming back to the core parameters which were pleaded out: torque and speed. It is not correct to say that Professor Hausberger confirms that the full range of torque and engine speed are used in normal driving. What he said was *"[y]ou can have at 5% of the time torque and speed close to the rated power and speed"*. That rather suggests that full torque and full engine speed are not normal (as one might instinctively expect to be the case most of the time). His evidence did show that the 95th percentile of normalised engine speeds per speed bin does not approach 1, even at 150kph. A normalised engine speed of 1 would be full rated engine speed. Even if driving well over the UK speed limit, the 95th percentile is some way off using full rated engine speed. This is an indication that there are engine speeds that are not NDC, but that may well be engine/vehicle specific. Professor Hausberger fairly acknowledged that there is no agreed scientific value for where the boundary of NEDC and engine speed may lie – the RDE approach starting with the 95th percentile described above was an attempt to map this. There is no data on engine torque in any of the available databases.

480. Given these difficulties Professor Hausberger's approach, relying on a consideration of the 95th percentile across a trip becomes more compelling. One way through the morass is to say that it is necessary to consider how frequently dynamic conditions are present in order to assess whether driving is normal. It also depends on the specific vehicle, its power, weight etc.

Legal Issue 2: "Reduction in effectiveness"

481. Legal issue 2 is "*what is meant by 'reduces the effectiveness' of the ECS under Article 3(10)?"*

482. One point of common ground is that RIE is a concept which requires further definition/clarification. Hence this issue. As has been explained above, to the extent that it was suggested that the meaning of the phrase has been determined in *CLCV* I reject that submission.

483. For the Mercedes and Mercedes-aligned Defendants this forms part of a wider approach to construction, which itself leads to the CRDD analysis.

484. However, for the Claimants and some of the Defendants, the issue then has two related parts, which themselves yield a number of further issues. The first is what is meant by the phrase "reducing the effectiveness" when used in Article 3(10). The second part is considering what the appropriate comparator is in order to establish reduction in effectiveness in any given case. That itself involves a consideration of how a comparator is established/constructed.

485. It may be said that this issue is the hinge around which the legal issues turn. For the Claimants "*RIE is the core concept that does the work in identifying what a DD is and by doing so is the main safeguard to ensure continued effectiveness of the ECS outside the test.*" For Mercedes and others it is accepted as a significant point, but for different reasons. For them the difficulties which they say are revealed as following from the Claimants' case forms an important part of the basis for rejecting that case.

486. One point requires to be noted here. Although the questions may be broken down into what conceptually comprises a reduction in effectiveness and what the comparator is for that conclusion, the division is an artificial one. The approach to RIE drives certain approaches to comparators: as will rapidly be seen below, an inevitable part of positing an approach to RIE is explaining how the existence of RIE is to be ascertained. And the implications of the comparators – in particular their practicality or even real-life impossibility - reflect back questions which test the RIE definition. For example, a definition of RIE which cannot be tested at all would have to be wrong. And it is agreed that *"the RIE test must be one that can be applied in practice – by manufacturers, TAAs, market observers, regulators, and customers."* So, how RIE works must be considered when considering the merits and demerits of the parties' theoretical analysis.

The Claimants' case

487. Subject to arguments about the extent to which the Claimants' case has moved, the Claimants' case may be said to be that:

    i) A "*reduction in effectiveness*" in the context of Art. 3(10) means that an alteration in the operation of any component or components of the ECS has occurred by moving from the calibration points operative in the NEDC to a different calibration point, which then produces an increase in tailpipe NOx emitted relative to that which would have been emitted but for the change;

ii) The relevant comparison (for identification of the "reduction") is between the effectiveness of the ECS in the NDC affected by the change (e.g. all NDC above 500m for an altitude device) with the calibration used in the NEDC (so with the EGR rate not reduced, AdBlue dosing still unrestricted, etc.). This requires an assessment by reference to the actual effectiveness of the system in any NDC as compared to the potential effectiveness that would be produced by using what the Claimants sometimes refer to as "*the base calibration employed during the NEDC test*".

488. However this summary neglects both to cover some of the variations or lack of clarity which have afflicted the Claimants' case during the course of the litigation or to explain what is inherent in that case in practical terms.

The lack of clarity

489. The Defendants criticise the Claimants' case on the basis that it has shifted and is inconsistent both internally and with previous iterations. A great deal of ink has been spilled on this subject, and quite a period of opening and closing submissions were also given to it. The Claimants have not engaged head on with those criticisms, in part because of the tight schedule, and in part, it has seemed, because they regard the Defendants as wilfully misunderstanding their case.

490. There may be elements of the latter, but I conclude that there certainly are difficulties in reading the Claimants' case as a coherent and non-shifting whole.

491. A key point is one which starts with an uncontentious fact: EGR is not static, in test or out. It shifts pretty much constantly. EGR does not run at 100% in test, or at 100% in part 1 of the test and 75% in part 2 of the test such that one can easily see a divergence out of test. And yet the Claimants' case appears to be founded on such static thinking. An example in their opening was "*at 10°C the EGR rate is reduced from the 50% EGR rate used throughout the NEDC to a rate of just 30%, and that 30% EGR rate would lead to an increase in the NOx produced in those off cycle NDC (whether or not those conditions, temperature aside, are caught by the NEDC) compared to the emissions produced by baseline EGR rate of 50%, that is a reduction in effectiveness"* and elsewhere (as noted just a few paragraphs ago) there is reference to *"the base calibration employed during the NEDC*".

492. A second key uncontentious fact is that in test a vehicle does not have to stay below the limits for NOx at all times. The performance is averaged, so it is perfectly permissible for a vehicle to emit more NOx than the limit for some of the time, so long as it emits less than the limit for a sufficient period of the test. Plus there is scope to fail the test and still gain approval as the test is conducted three times.

493. A third key uncontentious fact is that it is agreed that there was no requirement for vehicles to meet the same figures posited for the NEDC test out of test (on average or at all). That is not the way that iteration of the regulation worked.

494. This links to common ground between the experts (though not entirely accepted by the Claimants) that some modulations of the EGR rate (at both low and high temperatures) are necessary to maintain combustion, and hence do not constitute a DD. This was at points recognised by the Claimants, but cannot be reconciled with:

i) Passages of the Claimants' closing where they say that in order to establish a RIE of the ECS, all that they must do is to show a reduction in the EGR rate from that used in the NEDC, and that it is not even necessary to test the levels of NOx emitted from the tailpipe;

ii) Other passages in closing saying that that the RIE is established "*wherever there is a deliberate derating or cutting of the EGR rate*" or "*a parameter being sensed −−let's say, ... it 's altitude in a SCR system −−if upon sensing that I then ... half the rate of reagent dosing from the rate that had hitherto applied to minimise engine−out NOx and optimise their treatment, I reduce the effectiveness of the system compared to how the system was operating before the change*."

495. In addition the experts were clear that this work is not easy and there is room for judgment. There are challenges involved in calibrating EGR while maintaining combustion in a diesel vehicle, managing the risks arising, managing other regulated pollutants and delivering a product consumers actually want. It is for example common ground in the Ford GLO that:

> "EGR calibration is an exercise of judgment. There is a balance between the emissions (NOx, PM, HC, CO) emitted from the engine, emissions at the tailpipe, fuel economy, vehicle performance, and component life and risk of engine failure."

496. Those facts provide difficulties which the Claimants' case has strained to encompass. This has apparently led to at least a partial shift in the case:

i) The pleaded case on RIE was: that "reduces the effectiveness" means "*any element of design that senses the parameters set out in Art.3(10) and reduces the effectiveness of the ECS compared to that which would be produced by the settings operative during the…[NEDC] and the effectiveness in controlling emissions of the ECS during the NEDC*", and that a RIE "*is to be measured by reference to the potential effectiveness of the system in all conditions seen in normal operation and use*" (emphasis added). As regards EGR rates, "*any change in the EGR rate triggered by a parameter that reduces the effectiveness of that component of the ECS will be a DD*";

ii) In opening the Claimants submitted that RIE means "*moving from the calibration points operative in the NEDC to a different calibration point, which then produces an increase in tailpipe NOx emitted to that which would have been emitted but for the change*"; and that the relevant comparison was between the actual effectiveness of the system as affected by the change, and "*the potential effectiveness that would be produced by using the base calibration employed during the NEDC test*". Elsewhere they contended that the comparison must be between "*the calibration generating the test performance and the calibration used for on-road performance*";

iii) At the same time in oral opening and written closing the Claimants suggested that the hallmark is that a RIE occurs whenever there is a change in the operation of the ECS from how it previously operated (in some prior moment), the result of which is that more NOx is emitted at the tailpipe than would have been emitted had the change not been made – the difference being a comparison with the calibration

immediately before the change (whether in or out of test), as opposed to the calibration in the NEDC. See for example:

> "You compare the effect of the change of calibration in the circumstances, events, driving conditions that follow the change, you compare that with what would have happened if the previous calibration had remained unchanged. It is a comparison between two settings: one with the modulation happening and one with the modulation not happening and business as usual continuing in whatever driving circumstances follow the change."

iv) There are also suggestions that the methodology may change: "*Regulation EC 715/2007 ... does not prescribe or mandate a method by which that reduction in effectiveness is to be measured. How such reduction is best identified will depend on what is, or may be, reducing the effectiveness of the ECS.*"

497. As regards testing and how it feeds into the equation, the Claimants' case likewise moved:

i) The Claimants never exhibited any sign of disinterest in the JTP. On the contrary they wished to perform far more tests than there was time for, and the division of time for testing was hotly contested;

ii) In opening the Claimants both:

a) Posited a case which depended on a comparison between "*actual effectiveness*" and "*potential effectiveness*" of the ECS, which can only sensibly mean a comparison of tailpipe emissions, as tested;

b) On that basis the Claimants dropped a case on Swirl Flaps and Glow Plugs when their expert concluded that those functionalities did not reduce the effectiveness of the ECS;

iii) At the same time they submitted that RIE can be identified on the basis of "*desktop analysis*" without testing tailpipe NOx emissions, asserting that if the EGR rate is reduced from the "*rate used throughout the NEDC*" to some lower rate then (at least in an EGR-only vehicle) it necessarily follows that there is a RIE. This was also against a background where both mechanical engineering experts in the Mercedes Proceedings agreed that the relationship between these variables (i) only holds if all other factors are equal, which they rarely if ever will be and (ii) in any event is highly non-linear.

iv) In closing:

a) The Claimants went somewhat cold on testing: "as *a matter of law there is no prescribed way a RIE must be proven. This is a matter of evidence. Either or both of deduction through (i) analysis of the process from known facts about vehicle calibration, and the consequences of modulations produced thereby, or (ii) analysis of on-the-road emissions with the modulation on and off, can assist*";

b) The oral arguments in closing however also featured what may have been a circling back to the original case, in that the "template" approach emerged:

> "the prohibition of defeat devices is designed to ensure effectively.... that the emission control system template .... used to pass the test is thereafter used in all normal driving conditions so far as its use is consistent with safety.... The test allows you to set the template. The defeat device prohibition requires you to then use that [template] in all the normal driving conditions that haven't been caught by the test. Subject to the possibility of exception....
>
> So the purpose of the pillar 2 prohibition on defeat devices, and we suggest the only sensible rationale and a rationale self−evident from its nesting of Article 5(2) along Article 5(1), is to prevent the emission control system, the template used to pass the test, from being operated differently in the real world of wider NDC. You have to stick to your test template and that makes sense because without this further pillar, simply passing the test would be an empty or pointless formality which is the very central thrust of what the CJEU and CLCV rejects on effectiveness grounds."

498. Elsewhere the Claimants slightly qualified this by saying that only modulations generated by conditions substantially included in the test would be permitted; which begs the question of which included modulations are not substantially enough included, and thus must be excluded.

499. On changing of case, it is worth touching on a further point, materiality:

a) In opening the Claimants appeared to accept that materiality had a role e.g. via: *"any material change in EGR rate for a torque/engine speed not seen in the NEDC is necessarily*" a RIE;

b) In closing they emphatically rejected any materiality threshold.

500. To some extent one might view these points as somewhat arid; in trial derision is often directed at "pleading points". However the Defendants are right to say that in circumstances where the Claimants' case is that their approach is the correlate of the correct construction of Article 3(10) – and bearing in mind the importance of certainty in a major regulatory regime – the lack of clarity and the shifts in the Claimants' case provide questions which will require to be fed into the exercise of construction in due course.

The implications of the Claimants' case

501. The central point here is the width and extremity of the Claimants' case when correlated to actual practical vehicle operation.

502. The overall case combines several wide aspects. On RIE the Claimants take a very wide approach dominated by the proposition that any reduction in "*the EGR rate"* or "*efficiency of the SCR*" means a DD and a PDD: any degree of modulation of the ECS that (i) reduces the EGR rate from that applied during the NEDC test, or which (ii) means the SCR does not operate as fully as it possibly can in any NDC conditions regardless of

whether that might cause release of ammonia, constitutes a DD. That is then combined with wide approaches on:

i) Materiality/*de minimis*: the Claimants reject any suggestion that there is a materiality/*de minimis penumbra;*

ii) NDC: as already noted the Claimants again take a very wide approach. They argue for normal driving conditions including a temperature range from -15ºC (including parking at -15ºC for a week) to 40ºC;

iii) Article 5(2) justification: the Claimants contend for the narrowest possible reading of the exceptions.

503. This leads to the example given in the Introduction to this judgment: a device that reduces the EGR rate by a fraction of a percentage point from the level at which it would operate during the NEDC, for just a moment or two, and which operates only at -10ºC ambient temperature, is a PDD, unless it can be justified as necessary by reference to the precise calibration and by risks both as to safety and engine damage or engine start up.

504. There is therefore certainly the potential for the Claimants' approach to lead to the application of a far stricter emissions standard outside the test than the one which is applied inside the test. As has been explained, emissions in the NEDC test are collected in a bag and averaged and inevitably at some points during the test, NOx will be emitted from the tailpipe at a far higher rate than the applicable Emissions Limit. That does not matter so long as the average figure is OK. That is true even if the increase is the direct result of a modulation of the ECS, so long as the overall emissions across the test cycle are below the limit.

505. Logically therefore if the Claimants' approach is right, a calibration that generates higher NOx than the relevant comparator calibration will entail a RIE even if used for only a short time (such that it could not on the Claimants' case come within Article 5(2)(c) even if it had been operative in the NEDC), and even if the emissions overall would be below the Emissions Limits. The same would be the case if the emissions overall were within the more stringent RDE CF over an RDE test.

506. Indeed the logic of the Claimants' case is that:

i) Even a vehicle that meets, or would if they had applied have met, the RDE requirements, includes a DD, which (on the Claimant's approach to Article 5(2) ER) is unlikely to be justifiable;

ii) The RDE approach to conformity factors is entirely otiose. While the Claimants' say that Conformity Factors are simply rules of thumb ("*levels above which the Commission encourages regulators to investigate*"), their approach would suggest that no such rules of thumb were necessary and that emissions above test levels but below the conformity factor level were still evidence of DDs.

507. That cannot be right; however the Claimants have never really grappled with this argument and explained how their real case differs from that which is attacked, and how their real case (despite their instant by instant formulations) evades this problem.

508. There are other issues which emerge in the iteration of arguments on the individual CSVs. Can it, for example, be right that a derating of EGR is necessarily a DD even in a vehicle which has SCR and that SCR is calibrated to come into effect at the point when EGR is derated – i.e. where there are two NOx emissions systems working as a "tag team"?

509. The Defendants would also say that the Claimants' approach leads to the "*dream car*" paradox. The Defendants have submitted that the logical correlate of the Claimants' case is that the only permissible car is a "dream car" which:

    i) Can maintain the combustion of diesel fuel despite deficiencies in oxygen and temperature (and in defiance of the laws of physics);

    ii) Reduces NOx to the fullest extent possible in all non NEDC conditions, even if such NOx reduction is not necessary to meet the applicable regulatory standards, or desirable in terms of fuel consumption;

    iii) Complies with the tightest regulatory standards that apply anywhere in the world, regardless of the standards in fact applicable in the market for which it is intended. Any technology that was available anywhere in the world that could have reduced the need to modulate the ECS should have been included in both Euro 5 and Euro 6(b) vehicles;

    iv) Is designed and manufactured in a short period of time, with fundamental changes possible until the very last minute to permit it to incorporate any technology available to anyone, anywhere, up until the very moment it is Type Approved;

    v) Its volume is infinite, allowing space for all the technology it must necessarily incorporate.

510. As the Defendants note, the dream car comes at a price:

    i) To minimise NOx it will (i) freely emit other harmful pollutants such as PM, HC, CO_2 and NH_3 albeit somehow complying with other product safety legislation; and (ii) mitigate safety risks such as fire and acceleration failure only if they (a) involve immediate damage to a part listed at §3.3.1.2 of Annex 1 to the IR and (b) do not arise throughout most of the year;

    ii) It will cost more than these cars did. (It has become apparent from the preparations for the contingent quantum trial that this is part of the damage being claimed by the Claimants).

511. Again, the Claimants have not really grappled with the "dream car" argument – they have derided it as one of the Defendants "*buzz words*" but have not actually deconstructed it.

512. That the Claimants approach is to some extent fallacious, as the Defendants submitted, follows in part from the evidence (which was substantially agreed) that there is no one correct or perfect calibration for any vehicle. There will be a range of calibrations which are reasonable. There will be a range of calibrations within which it cannot be said that there is a reduction in effectiveness. Professor Tunestål agreed that "*different engineers and different manufacturers can, and probably will, reasonably reach different conclusions about the calibration of a particular vehicle*". Professor Martinez-Botas accepted the proposition that there's "*more than one reasonable calibration of a diesel*

engine". Mr Carder accepted the proposition that "*there's a range of calibrations which are reasonable*."

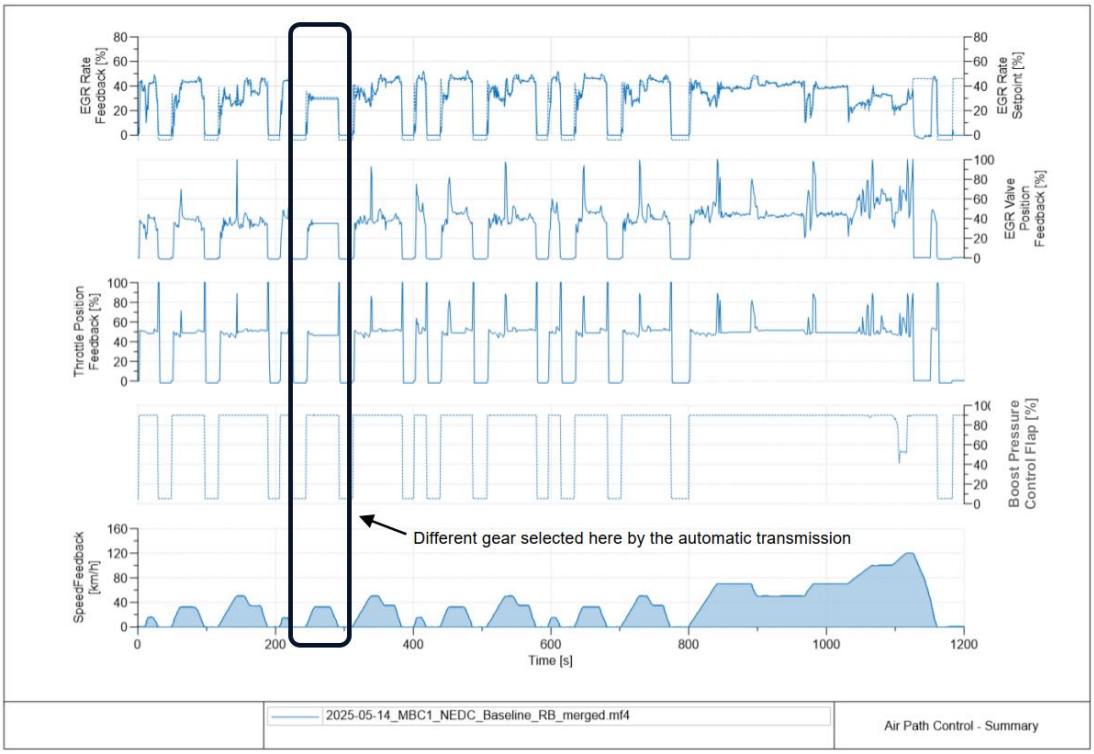
513. The net result is that I conclude that there are real, valid and substantial criticisms of the Claimants' primary case on RIE.

514. As for the new case (arguing that the relevant comparator is to the EGR rate in the Test), the logic of this argument suggests that there is only a single permissible EGR rate in all conditions; which is contrary to the accepted expert evidence that modulation of the EGR rate is both inevitable and necessary.

515. The Claimants often seem to posit a static EGR rate during the NEDC test: "*an EGR rate of 50% during the NEDC test must also be operative at 50% in normal real-world conditions, except when there is an Art. 5(2)(a) justification to modulate the EGR rate downwards.*" Or *"the 50% EGR rate used throughout the NEDC*" or *"the base calibration employed during the NEDC"*. This is a significant problem for the Claimants' approach because (as the Claimants accept) the EGR rate will not have been a static 50% during the NEDC – the NEDC rate ascertained is an average. The EGR is constantly modulated and within the NEDC a wide range of EGR rates are run.

516. Two examples are illustrated below:

a) Figure 4 of Appendix 2 to RD1 plots both the EGR Rate Setpoint (i.e. the demanded EGR rate) and the EGR Rate Feedback (i.e. the sensor modelled actual EGR rate) throughout the NEDC Baseline test for MBC1, IF. It shows that the EGR rates utilised during the NEDC test range from 0% to around 45%;



b) Figure 132 of Mr Carder's Report plots the EGR rate in FC6 in the Baseline NEDC test which shows FC6 employs EGR rates from c 40% to 0% in the NEDC test itself;

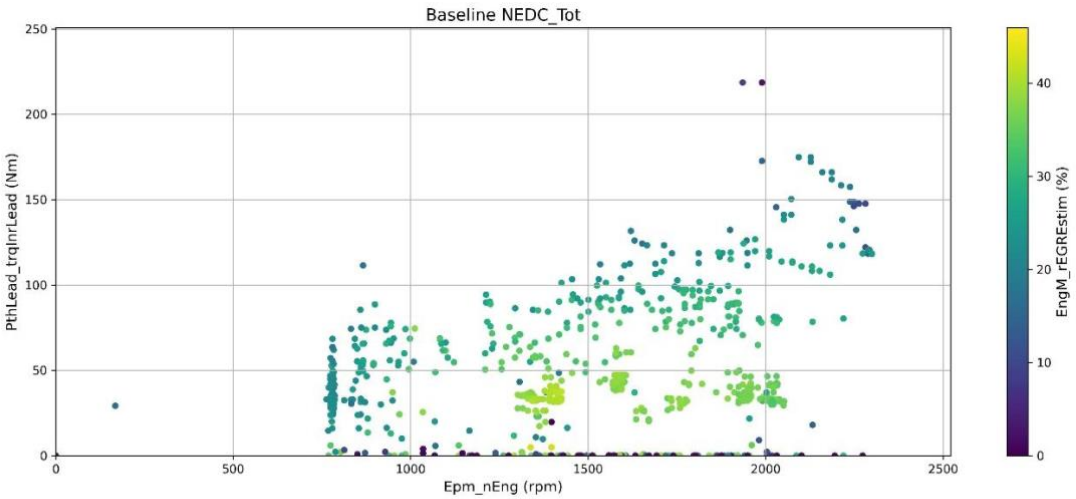


Figure 132 Baseline NEDC Speed-Torque Operating for FC6

c) That means that the reference to an "*EGR rate used throughout the NEDC*" is incoherent: there is no such rate, but rather a range of rates which, overall, produce a rate of NOx emissions that overall and averaged meets the limits set by the Emissions Regulation.

517. There are a wealth of similar plots which can be used to demonstrate the same point. So, if what is being said is that the rate should be 50% at all times, this is an apples and oranges comparison – the agreed facts are that during the NEDC test a modulation that reduces the EGR rate below that figure will not necessarily cause the vehicle to fail the Test. So any solution calling for a single rate would be requiring in real life that which is not required in test conditions.

518. The problems only intensify when one begins a search for comparators. Because nor is it feasible simply to compare the average percentage achieved – that covers driving precisely under the conditions of the NEDC. The only valid comparator for that would be another NEDC drive – which is not a normal driving conditions drive.. One way round this would instinctively seem to be to snapshot thousands of short markers during the NEDC test and then extrapolate them to real life driving conditions. This is similar but not identical to Mr Smithers' approach (derided by Mercedes as "*the julienning approach*"[7]) which is comparing small slices of data showing the performance of specific components of the ECS within the NEDC with similarly small slices of data showing the performance of those specific components of the ECS in other test conditions.

519. However, as Mr Raoul Day explained, this is artificial and unlikely to have been intended given that real time measurements are not taken as part of the Type 1 test. They are only available in this litigation through the specifically designed JTP. And such an approach is conceptually in tension with the fact that the NEDC test is an averaging test. It does not make sense to evaluate the effectiveness of the ECS by reference only to a particular

[7] Arguments are often derided as "*salami slicing*". Mercedes' point is that the Claimants' approach takes the salami slicing approach to a whole new level.

spike or segment of NOx emissions at one instance within that test duration. Finding a "*higher emission slice*" obviously does not mean the vehicle contains a DD.

520. Further the snapshot comparison has its own problems – of a range of complexity. Starting at the simple end, even if it could be done it is not a like for like comparison – real world conditions (even those which mimic the NEDC conditions) produce worse results than an NEDC test. This is one reason why when the RDE Regulation was enacted it provided for conformity factors. In other words, a simple 1:1 correlation with performance on the NEDC was not required because it was understood and accepted that emissions performance was likely to be worse on the road than under Test conditions. While there was a debate about the extent to which the conformity factors were addressed to uncertainties of the test procedure and of the measuring equipment and to what extent (as per recital 10 of the RDE Regulations) the aim was to tighten up on emissions gradually, both the drafting of the relevant regulations and the evidence justified the conclusion that the same car tested on a dynamometer would perform better than a vehicle running the same cycle on the road.

521. At a more detailed level further problems emerge. If one goes down the segment route, how does one find "comparable" segments? As the rules about averaging and allowing a single test failure suggest, the evidence is that for any given Dyno Test the result could be within the range of up to +/-10% of the result for an identical test. So where comparisons are based on comparisons of single Dyno Tests, these types of comparisons could involve variations of up to +/-20% which would not necessarily be demonstrative of any real difference in emissions levels, but only of intrinsic variation. Second, as Mr Day explained, the slicing approach in fact increases the relative impact of errors; when only a slice of singular test is considered, "*each error constitutes a larger proportion of the total data*". When the full test is considered any errors are, in effect, spread across the test, and hence are averaged out in the +/- 10% range. With a very narrow slice the result could in theory capture only errors.

522. This practical difficulty with the snapshot approach appears to be one factor which has led the Claimants to adopt what in closing was called the *"template approach"*. This equated roughly to saying that it was open to manufacturers to pick a template or portfolio of calibrations which they would then deploy in the NEDC test; and that outside of the test they must use that template or at all times use one amongst the portfolio of calibrations. It seems likely that the argument to some extent draws on the BES/AES approach of the Euro 7 regime – but of course lacks the flexibility inherent in the ability to agree emissions strategies outside the base strategy.

523. As for the "template" analysis, this was unpleaded and not the subject of cross-examination. It appears not to be intended to apply to SCR systems. For current purposes it is however pertinent to note that it too has considerable practical issues. In broad terms it would create a calibration straitjacket for the manufacturers, which it is hard to imagine could produce a car which was an attractive drive. But it would also have logical anomalies. In closing Ms Davies KC illustrated how EGR rate changes at 1,700rpm (outside the test range) which were essentially identical to those made within the test would nonetheless be DDs on the template approach simply because the engine speed is not covered by the test; so the limits of the test would itself create DDs. Again this raises questions as to the robustness of an approach which leads to this conclusion.

The Defendants' cases

524. All of the Defendants agree that the Claimants' case is either far too wide or far too vague. The Defendants agree that the Claimants' case either approximates to requiring NEDC results outside of the NEDC (which the Claimants accept is not the case) or it is hard to see to what (workable) approach it does approximate.

525. Thus far therefore the Defendants' case made common cause. However, they do not agree on what a reduction in effectiveness is or how it is to be ascertained – in part because it is agreed that there is no prescribed or empirically accepted method for measuring the effectiveness of an ECS or a reduction in effectiveness. In part, however, this range of approaches is reflective of the divergence of views about CRDDs.

526. Thus Mercedes' definition is designed to correlate with its case on CRDDs; saying that the only interpretation of Article 3(10) that is reconcilable with the ER and its travaux, the case law and the principle of legal certainty, is that a RIE is shown if the ECS senses when the vehicle is being tested and causes differential operation in that scenario compared to when it is not being tested.

527. Ford in opening extended this approach to Article 3(10) to boundary devices (i.e. to devices calibrated to Test boundary conditions) and but for which the Test would be failed. PCD adopts the CRDD approach as its primary case. As a secondary case however it rests on the Testing Out approach supplemented by a strongly urged case on materiality. Nissan's primary case is also CRDD. Nissan's secondary case is a very much modified version of the Claimants' case based on Testing Out and Conformity Factors.

528. Renault alone of the ALGLOs pursue as their primary case a broader case, called "the Holistic Approach" which looks at emissions overall and not on a pollutant by pollutant basis.

The "axiomatic" relationship between EGR rate and NOx

529. This is one of the key issues in this case, because it has a very powerful impact on the reduction in effectiveness arguments, effectively determining whether RIE can be proved via a desktop analysis only, or whether the enquiry needs to be more expansive and multi-factorial.

530. A repeated theme in the arguments was the Claimants' assertion that less EGR meant more NOx – and that the relationship was "axiomatic". The Defendants' response was that while, "*all else being equal*" that was right, all else was never or almost never equal in this context – in that a reduction in NOx would have other trade-offs or that temperature can affect the effectiveness of the EGR.

531. As to trade-offs, those definitely exist and are of different types. One sort of trade-off leads into the holistic argument. Mr Chappelle said this:

> "Well, nature is not generous in all aspects. So when you develop an engine, you have always to make compromise. Compromise you have to make, for example, is NOx versus CO_2".

532. Thus EGR, whilst reducing the production of NOx, can cause an increase in other emissions. This is because, in reducing the temperature of the combustion chamber, and

thus limiting NOx formation, combustion becomes more difficult and there is a greater degree of incomplete combustion, generating CO, PM and unburned HC. EGR also increases CO_2 which is regulated on a fleet-wide basis. This particular sort of trade-off only matters therefore if one embraces what is known as the Holistic Approach – dealt with in a few sections' time.

533. But trade-offs go wider. Mr Carder refers to "*these other sort of extenuating circumstances which can influence the NOx number",*in essence saying that all else is not always equal. That was rightly (if tacitly) conceded in the Claimants' Closing where it is said that opening the EGR valve (and hence increasing the EGR rate) will *"generally (indeed in the great majority of circumstances) produce more engine out NOx"*, thereby correctly recognising that that will not be the case in every circumstance.

534. One example of all else not being equal is temperature, this was explained thus by Professor Millo:

> "[a]t higher loads, the exhaust gas composition changes; it contains a higher concentration of inert species (CO_2 and H_2O) and less residual oxygen. This makes the recirculated gas more potent in suppressing peak combustion temperatures. Consequently, a smaller percentage of this high-load exhaust gas can achieve the same or even greater NOx reduction effect as a larger percentage of low-load exhaust gas."

535. Similarly:

    i) At higher loads a lower EGR rate can be just as effective at reducing NOx as a higher rate would be at a lower load;

    ii) There were some examples in testing of EGR derates having no meaningful impact on NOx;

    iii) The JTP in Ford tended to demonstrate that the CSVs maintained effective EGR despite the reduction in EGR percentage as torque and temperature increased.

536. Another example which can be taken is the Claimants' case on the delightfully named "Swirl Flaps" and "Glow Plugs". This was advanced on a desktop basis and was then abandoned when the test results demonstrated that theory and practice did not coincide: Mr Smithers concluded that those functionalities did not reduce the effectiveness of the ECS. It is fair to say that the Claimants markedly avoided dealing with the implications of this episode for the axiomatic NOx case.

537. The answer appears to be accurately stated that if and when all else is equal a reduction in EGR percentage will mean an increase in engine out NOx; however, it cannot be assumed that all else is equal. There is a significant portfolio of circumstances in which it is not. That may well be one reason why a testing regime was introduced in the first place.

538. Desktop analysis depends for its validity on the incorrect assumption that in every case a reduction in the EGR rate will lead to an increase in engine out NOx. That is (at least sometimes) accepted by the Claimants to be wrong. It is for the reasons given above plainly analytically wrong.

539. What follows from that is a point of considerable practical significance: that where the Claimants allege PDDs where proof of RIE depends on desktop analysis/the axiomatic principle only, those allegations will often fail. The question of the so-called axiomatic NOx reduction case cannot be determined at large – it is necessary to look at each allegation and see whether it is possible to say, on the evidence adduced whether the general rule operates, or whether on the evidence a modification to it is relevant; or whether in the absence of evidence the "axiomatic" approach can establish RIE.

Reduction in effectiveness: the empirical issue and de minimis

540. Before leaving reduction in effectiveness one marker should be put down, for issues which come into play when the technical side of the case meets the legal side.

541. The intricacies of the testing regime and how a robust testing programme was sought to be designed have been addressed above. The reality was that getting any sort of a robust testing regime in place was not entirely easy. There remained difficulties in devising tests to ascertain all relevant facts, as well as in scheduling all the tests which the combined ingenuity of the teams could devise. In the end, difficult decisions had to be made as to which tests to pursue and which to drop. The reader will also see, when the individual CSVs are considered, how testing at some points did not work, or did not operate entirely as anticipated (e.g. when Mahle tested with a bonnet open). And even where test results were obtained as planned those results are not absolute "set in stone" results which *per se* demonstrate reduction in effectiveness.

542. Sometimes it may be the case that the testing regime demonstrates a very obvious reduction in effectiveness. But questions inevitably arise when the difference between the regulation figures and the tested figure is less striking. Can this court be satisfied on the balance of probabilities that there was a reduction in effectiveness if the difference is small (say 10% or less) given that:

    i) It is accepted that there can and will be a variation on performance between two tests, even on the dynamometer, and still more so on the road. It is essentially for this reason that the testing regime for type approval did not require the test to be passed on every occasion;

    ii) While in service conformity was aimed at, it is accepted that performance will worsen as a vehicle ages. Thus the regulatory framework at this stage stopped before 160,000 kilometres. All of these vehicles were well past the first flush of youth;

    iii) Most of the vehicles had had upgrades applied over the years and testing was done on "*rolled back*" software.

543. An example of the kinds of issues raised can be seen in relation to the "testing out" arguments for PCD split mode where the Claimants identified the following issues: "*Because the CSVs are necessarily aged, all but one of the standard NEDC tests performed on the Euro 5 CSVs in the JTP exceeded the emissions limits ... Accordingly, other than for the one test with a CF of 0.90, it is not possible to use them as a "test pass" comparator by which to assess the Testing Out defence. Instead, Mr King has taken the mean percentage change in NOx emissions caused by split mode on the basis of his analysis of the NEDC + 10% analysis and the open ECU tests, and applied it to the type*

approval NOx emissions … This involves comparing emissions results obtained in vehicles in the JTP on aged vehicles in 2025 with those obtained on different vehicles (the type approved vehicle was of the same type as the CSV but was not the CSV) in type approval tests carried out more than a decade ago. The problem with that is that as Mr King put it: "There will be a spread of emissions performance from vehicle-to-vehicle, due to the various tolerances in components and assembly – there is no way to assess where these particular vehicles would sit within this tolerance cloud, given their emissions performance when brand new was not measured"".

544. These difficulties are of course one reason why the Claimants urge the force of the axiomatic approach.

545. Where some of the Defendants took this was into an argument about materiality – positing that there must be a materiality threshold. Mercedes says that there must be a "*significant and material RIE*". Other Defendants nuanced this with varieties of significance or materiality deployed.

546. The Claimants are right that the language of the ER does not suggest a materiality threshold for RIE. Art 5(2) ER prohibits DDs that "*reduce the effectiveness*" of the ECS without any qualification, in direct contrast with Art 5(2)(c) which only a few lines later in the same sub-article permits DDs where the conditions are "substantially" included in the test procedures. No similar adverb (materially, substantially etc) is used to qualify the prohibition on RIE.

547. The Claimants are also right that the authorities to date have not been sympathetic to this approach:

    i) The Administrative Court VG Schleswig-Holstein noted in its decision of 20.2.23 at [259(bb)]: "*According to the wording of the provision, any reduction in the effectiveness of the emission control system is covered, i.e. any relative change in the comparison of two values. The degree of change is therefore not important*";

    ii) A similar approach can be seen in relation to other regimes – see for example judgment of 15 May 2025 *Verbraucherzentrale Hamburg E.V. v Bonprix Handelsgesellschaft MBH* C-100/24 EU:C:2025:352 (e-commerce), judgment of 4 May 2023 *UI v Österreichische Post AG* C-300/21 EU:C:2023:370 (GDPR).

548. However at the same time there is some authority for a *de minimis* exception, even where not expressly provided for. Reference was made to Case 5/69, *Völk v Vervaecke* [1969] ECR 295 (which is often cited for the proposition that an agreement may fall outside Article 101(1) if its effect on competition is insignificant/*de minimis*).

549. In *Crossley 1* at [192] Waksman J skated over the surface of the argument, on the entirely sensible basis that it did not apply in that case (where in Mode 2, the vehicle would have been incapable of passing the NEDC test).

550. Given some of the results in testing, this sensible approach is not available to this Court. I accept the Claimants' submissions that the materiality argument is misconceived and runs contrary to the wording of the regulation. I also am not minded to conclude that there is a single blanket *de minimis* percentage figure applicable in all cases. That is challenging for some of the same reasons as the Claimants submitted in oral reply.

551. However as the Claimants pointed out, *de minimis* arguments and proof are not the same thing. At the level of proof (and unfortunately for both writer and reader, on a case by case basis) the conclusion as to RIE must take into account these factors – as well as, on occasion, questions of design intent. There will be cases discussed below where the marginal nature of the deviation from test results, combined with the factors I have highlighted lead either to the conclusion that there is a breach by a very small margin, or that I am not satisfied on the balance of probabilities that there was a reduction in effectiveness.

The complications of SCR for identifying RIE

552. The particular complications of SCR derive from the two elements to the process, namely that AdBlue dosing is not the direct cause of the conversion of Nox to neutral components. SCR works, as described above, by a reaction between the NOx and the ammonia stored on the catalyst. It takes place on the catalyst, and the amount of ammonia which the catalyst can store depends on a range of factors including temperature and its storage capacity.

553. If a storage catalyst is full, ammonia will not absorb, but will result in ammonia slip. This, however much one may argue about its seriousness, is not a desirable result.

554. Given that set of facts, it becomes genuinely difficult to work out how an SCR's efficiency is affected by AdBlue dosing. More dosing does not correlate to more efficiency. If a catalyst is full it will be better not to dose until storage space has been freed up. As the Claimants put it in opening "*Variable dosing to reduce ammonia slip is not a per se reduction in effectiveness and can be permissible, providing either that it is substantially implemented in the NEDC test or does not affect the effectiveness of the SCR (as sufficient dosed and stored ammonia remains available to maintain the same effectiveness level)*".

The Holistic Approach

555. The third distinct case offered is that of Renault: the "Holistic Approach". This approach was adopted to a greater or lesser extent by Ford and Nissan. It may be seen as a development from the agreed position that EGR modulation has knock on effects elsewhere that when calibrating EGR, it is necessary for an engineer to consider the impact of EGR on all regulated emissions and not just NOx.

556. This was pleaded thus:

> "... a feature which "reduces the effectiveness of the emission control system" is one that makes the ECS work less well overall.
>
> The question of whether the ECS works less well overall requires the exercise of a broad evaluative judgment, taking into account all the circumstances, including the overall effect of having (and not having) the said feature on emissions levels generally. It is a multi-faceted test, and not susceptible to simple measurement.
>
> The test of "effectiveness" is not measured by reference to a single snapshot in time, but requires a broader perspective on the overall operation of the ECS as a coherent system. For example, an element of the design which

results in a brief increase in NOx during part of a car's operation and use, but a reduction in NOx overall over the course of a typical journey would not be regarded as a defeat device by virtue of the brief increase in NOx recorded in a short period.

The test of "effectiveness" is not measured by looking solely at one tailpipe emission, but requires an overall assessment, which includes the impact of an element of the design on other emissions. For example, a device that leads to an increase in NOx, but a reduction in particulate matter, would not necessarily be a defeat device by virtue of the increase in NOx viewed in isolation.""

557. This argument was run in embryo in the *Crossley* case and was summarised by Waksman J thus:

> "…reduction in effectiveness of the ECS is not to be measured by reference only to NOx emissions but emissions overall. Since there is no evidence that overall there is any reduction in the effectiveness of the ECS when assessed on this "holistic" basis (and indeed, it is recognised, for example, that when EGR is operating, there is likely to be an increase in the production of particulates) the final "reduction" requirement of the definition is not made out; I refer to this as "the Holistic Argument"

558. Unsurprisingly, this argument was put with great persuasiveness by Mr Antelme KC for Renault. Anyone who has read this far in this judgment can probably feel a real sympathy with the view that a system which requires each emission to be considered and calibrated for separately, when in practice doing something to decrease one emission may well lead to an increase in another (e.g. NOx vs particulate matter or NOx vs CO_2), is cumbersome and complicated to a concerning degree. There are certainly attractions in an approach which brings the different pollutants into a global consideration, more so to anyone who has any sense of the history of automobile technology.

559. Certainly my impression also when listening to the evidence of Dr Davies was that he was entirely sincere when he said:

> "What I'm trying to articulate is the fact that if you take NOx, for example, that on-cycle or as your NOx changes, so does the other regulated gases and the calibration process and the overall calibration philosophy is to have an effectiveness of control across all of the regulated gases and this is saying that what we shouldn't be doing really is just doing a focused effort on one gas, it's really looking to ensure that you have effective control across all of the gases that are regulated."

560. However the argument simply cannot be right. It has attractions, but they are the attractions of the "fudged" answer. Unsurprisingly Mr de La Mare KC had a range of memorable critiques, of which two may be selected. In opening he described it as "*a Trojan Horse for subjective manufacturer judgment*". In closing, there was a longer but very telling blow:

> "Take the holistic argument. Where you end up with on the holistic argument, …, is you end up with what a public lawyer calls a non−justiciable decision. There are so many factors in play that anyone can arrive at a

> reasonable subjective judgment about the interplay between those factors. It is an unpoliceable test. It's not meaningfully capable of enforcement. That, if that is the end output of the argument, is not a credible output."

561. In my judgment, that criticism is correct. The result of the Holistic Approach is in essence a non-justiciable decision. It eschews uncomfortable analysis for comfortable and unmeaning vagueness, which cannot be right in the context of the legislative history. Further a fatal fault line in the argument is there in Renault's own pleaded case: "*The question of whether the ECS works less well .... [is] not susceptible to simple measurement*." The problem with this is that one thing which is plain on the face of the Regulation is that it is based on identified measurements of individual emissions.

562. Then there is the problem of, once one goes down this route, where does one draw the line? The Defendants who followed this course did not speak with a single voice. Just regulated pollutants? Or regulated pollutants and fuel (Ford's preference in opening)? Or all emissions, fuel economy and consumer health and safety factors (Nissan)? Or Ford's formulation in closing:

> "Article 3(10) cannot be read so as to mean that the mere fact that, in the exercise of its reasonable engineering judgment, an OEM takes into account factors such as engine and component life, maintaining combustion, loss of performance such as to make diesel cars unattractive to drive (such as a substantial risk of stalling in unsafe conditions) as well as fuel efficiency/reducing CO2 emissions when calibrating the emissions control system involves a reduction in effectiveness merely because that calibration has some effect of increasing NOx emissions."

563. It was perhaps not surprising against this background that Renault effectively offered an open menu card of options for the delectation of the decision maker. But that approach itself demonstrates the impossibility of the case being advanced. Even if the result is a test which does not quite fall into the trap of being devoid of content, as the Claimants suggested, the tentativeness and shifting of the Defendants' cases on this approach exposes the lack of certainty which would result from such an approach. It cannot be the case that the legislator intended to impose a test whose contents were so impossible to discern.

564. This then feeds into the next valid criticism of this approach – the way that it is in unresolvable tension with the actual wording of Article 3(10), which plainly posits some sort of counterfactual. Different counterfactuals can be proposed for the CRDD approach and varieties of the Claimants' case; but it is simply impossible to see how a counterfactual could be constructed for the Holistic Approach.

565. The next aspect of the criticism which might be (though was not in detail) made is the practical concomitant of such a test. While urging the realism and good sense of a joined-up approach, Renault and its followers steered well away from grappling with how such a test would actually operate. A moment's thought gives a glimpse of the difficulties of trading off one emission against the other – even before the non-regulated aspects start to be brought in. And, as the Claimants pointed out in closing, there was no evidence at all that Renault (or other devotees of the Holistic Approach) ever at the time sought to perform such an assessment looking at the effect of NOx emissions changes on other emissions.

566. Finally and returning to solid ground, this argument has in effect been rejected before. The argument in embryo was one which was run in *Crossley*. As the Claimants noted in closing, the version run was narrower than some in this case (a pollutant only form: if one regulated pollutant goes up, but another goes down, no DD).

567. Waksman J held as follows:

> "248. There is, in my judgment, an initial problem with this argument which is that it ignores the fact that the test, the passing of which is a prerequisite for type-approval, does not assess emissions on some global basis. Each relevant emission is assessed by reference to the particular limits and in some cases combinations of emissions are assessed also. Each relevant limit must be observed. In the case of diesel vehicles these are carbon monoxide, NOx, particulates, and the combined mass of total hydrocarbons and NOx together. Equally, the details of the type-approval set out those various limits. There is no concept of "swings and roundabouts" in the test. Indeed it would be wholly illogical to do so since excessive levels of each particular emission are undesirable in themselves.
>
> 249. If the above is correct, then it is very difficult to see why a defeat device should be such only if there is some overall reduction in emissions taken as a whole even though (for example) it unquestionably produces excessive levels of NOx.
>
> 250. And even if some global emissions comparison was appropriate, it is very difficult to see how such a comparison could be conducted, how much weight should be given to the increase (or decrease) of one particular emission as opposed to another and so on.
>
> 251. Equally, there is nothing in the language of Article 3 (10) or its precursors to mandate such a holistic approach. The effect of the ECS will be reduced if increased levels of NOx result from the de- activation of EGR because the NOx emissions will no longer be effectively controlled."

568. This decision is probably ratio (see [267] of the judgment which demonstrates that if it had been right, it would have precluded a conclusion that the device was a defeat device). But in any event, there is nothing in this analysis with which I remotely disagree.

569. All of the above means that the Holistic Approach can be rejected.

Comparators

570. The parties have therefore put forward a number of comparators designed to ascertain whether, if the Claimants' approach to construction is correct, a reduction in effectiveness can be ascertained. Each of these proposed approaches has strengths. But equally each is open to real criticism. In the section below the approaches and the issues which they present are outlined. It will be seen that none of them can be embraced as a universal comparator, and that none is without difficulties.

The Extrapolation Approach

571. The first important comparator approach advocated by the Defendants is the "Extrapolation Approach" contended for by PCD and Mercedes. In essence, it is said that there is no reduction of effectiveness where the performance of the ECS outside of the NEDC remains in line with an "appropriate increase" in the Emissions Limits taking into account a range of factors including (without limitation) any change in engine load and speed. This is done by reference to the so called Conformity Factor ("CF") – a multiplier to take account of harsher real world conditions.

572. In essence this approach accepts as a starting point that Emissions outside the NEDC may be higher, and seeks to delineate what may be an acceptable rise – and what may give rise to concern.

573. This approach has a number of attractions, not the least of which is that this is effectively the approach taken by the later emissions regulations. Thus the 2017 Commission Guidance or DfT guidance says that they are suspicious of vehicles that produce tailpipe emissions above certain CFs multiplied by the Emissions Limit, and that these reflect rules of thumb as to the levels of increased emissions that, knowing nothing more, are themselves sufficiently increased relative to the NEDC to make the use of a DD a very real possibility to be checked. These rules of thumb do not mean either that cars are entitled lawfully to produce emissions up to those CFs or that they prove a DD. They are effectively a screening tool. But they do provide a benchmark, and one which was plainly regarded as sufficiently credible and robust to be adopted by the regulators.

574. The Claimants decry the use of this approach. They naturally point to the fact that it is not grounded in the wording of the ER, which gives no hint or suggestion that adjusted limits are permissible. The Claimants also understandably draw attention to the lack of any definition of what an "*appropriate increase*" is or how any test might be conducted. As such in their view the approach is both indeterminate and speculative, and lacking in the certainty one would expect from a regulatory approach in this context. They criticise Mercedes' contention that if the results extrapolate to below the requirements of a later test there can be no PDD on the basis that if the drafters had intended to apply Emissions Limits with CFs to conditions outside the test, they would have said so and that the CF for the RDE test was intended only to deal with the imprecisions of the RDE test.

575. The Claimants also contend that this approach elides into the Holistic Approach. This is a less compelling argument. The two approaches do very different things – with the Holistic Approach avowedly looking at balancing impacts on other pollutants while the Extrapolation Approach remains centred on NOx with the trade-offs being implicit and not part of the calculation. The Claimants' criticism here is really another aspect of their lack of certainty criticism and their distaste for the role of judgment; however on the evidence it is clear that calibration does involve judgment.

576. Ultimately, the Claimants argue that the Extrapolation Approach is wrong conceptually because *"the key role of the DD definition, in an off-cycle scenario where the Emissions Limits do not apply, is to ensure that the compromise or equilibrium resulting from the calibration used for the NEDC is carried over to off cycle NDC"* and because *"the emissions scheme as a whole simply does not permit the kind of trade-offs in emissions for which Mercedes and PCD contend"*. This has truth – and that is the challenge for the finding of an appropriate way to extrapolate; but it also demonstrates part of the problem

for the Claimants' own argument. The ER is not trying to ensure achievement of the NEDC limits out of test; and if it is not, and if there is (as the Claimants explicitly concede) a compromise or equilibrium to be "carried over" without being imposed, then how is that to be done without some adjustment, such as a conformity factor? The Extrapolation Approach is not perfect, but it is less imperfect than many of the alternatives.

The Tailpipe Approach

577. The next comparator is the "Tailpipe Approach" an argument that there is no reduction in effectiveness if it can be shown that the activation or deactivation (as the case may be) of the functionality in question has no significant impact on tailpipe emissions, so the effectiveness of the ECS should not be reduced. To some extent this approach is uncontroversial. It underpinned the testing regime. The Defendants rely on it heavily (in conjunction with extrapolation in places), and the Claimants themselves abandoned certain allegations when testing showed no difference in NOx emissions when certain allegations (Glow Plugs and Swirl Flaps) were tested for.

578. At the same time however the Claimants reject it as a definitive test, arguing that it wrongly equates measured change with reduction in effectiveness. For the Claimants, it is very important to preserve the possibility of proving RIE via demonstration of the operation of the ECS and consideration of the chemical/engineering relationships involved (such as derating of EGR or reduced dosing having a clear theoretical relationship with NOx production).

579. The Claimants also submit that it is systematically under-inclusive in that it fails to capture boundary devices. The Claimants complain that it is an approach that says, tacitly, no changes that take place outside the torques or loads or engine speeds produced by the NEDC can be a DD. And it is unclear how this test works for a temperature device. A test that asks whether deactivation of a thermal window produces a change in NEDC result is obviously meaningless.

580. There are also further issues. The first is as to the practicality of the comparison given that the NEDC does not test tailpipe NOx on a second by second basis so as to have a check for levels of tailpipe NOx. The only way of testing second by second tailpipe NOx is to set up, as was done here, a testing regime – which, as is made clear above, is vastly complicated and expensive and imperfect. This is the Claimants' preferred approach – to test tailpipe emissions with the DD against tailpipe emissions without the DD. There are other issues with this aside from complication and cost. One is that the levels of tailpipe NOx can be affected by a very large array of factors, so that unless all other variables are identified and stabilised (not always possible) it is difficult to say that any change in tailpipe emissions logged are caused by the particular calibration or device being tested.

581. Further, other practical issues are highlighted by the fact that the parties part company on how this is tested if it is to be tested. Mercedes contend that testing for this theory "*requires deactivation of the functionality alleged to be a PDD*", with the relevant deactivation tests being NEDC tests. This produces what is effectively a controlled laboratory comparison centred on the relevant benchmark. This of course is the only way of achieving an average to average comparison - but presents as an oddity for testing performance in non NEDC NDC.

The Testing Out Approach

582. The fourth comparator is the "Testing Out" approach, which is relied on in some form by many of the Defendants. In summary: there is no PDD unless the vehicle would have failed the NEDC test with the modulation at issue turned off, and so RIE is always to be established by NEDC dynamometer testing. As Mercedes puts it: "*The core obligation on manufacturers as regards emissions, under Art.4 ER, is compliance with the Emissions Limits, which only apply during the NEDC. It is nonsensical to suggest that a functionality is a DD if that functionality has no effect on compliance with that core obligation."* This approach allows raised NOx levels to some extent – so long as the vehicle would still pass the test.

583. It is advanced by Mercedes, Ford and PCD as follows:

    i) Mercedes: "*there is no reduction in effectiveness if Emissions Limits would be observed in test conditions even in the counterfactual scenario in which the functionality is deactivated or activated (as the case may be)"*;

    ii) Ford: "*A "reduction in effectiveness" refers to a device that makes the vehicles emissions performance worse such that if the NEDC was run with the DD function disabled the vehicle would fail to meet the Emissions Limits";*

    iii) PCD: *"there is no reduction in effectiveness if not activating, modulating, delaying or deactivating (as the case may be) the relevant part of the ECS, i.e. removed the alleged DD, would not cause the vehicle to breach the Emissions Limits in Test Conditions"*.

584. The Defendants also point out the analogy to the Testing Out approach which can be found in the regulations. First in the IR at paragraph 3.13.3 which permits regenerations (e.g. of a DPF) so long as the NEDC limits are not breached. Secondly, they point to the Euro 7 (current) regulatory approach (referred to above) which allows AES modifications to be used instead of the BES approach so long as the vehicle passes the NEDC test.

585. The Claimants reject this approach, saying that it is tantamount to saying that off cycle reductions in effectiveness are irrelevant, which is impossible to reconcile with the ER or CJEU case-law. The Claimants contend that just as the concept of a DD does not require the Emissions Limits to be met outside the test, similarly a DD is a DD whether or not the Emissions Limits are or would sometimes or always be still met under its operation within the test. A DD arises where a relevant modulation reduces effectiveness of the ECS in non-test conditions. The reduction does not have a prescribed starting level or finishing level, it is a question of direction – of turning off or down the NOx control system.

586. In addition, it is said that the Testing Out Approach reading entirely disregards the wording of Article 3(10) ER by which a RIE is identified to occur in any NDC (which include the NEDC Zone only as a very small part). It is a huge and unjustified leap to read that as requiring that the settings applied would lead the vehicle: (i) to have reduced effectiveness in the test and (ii) that this be to such a degree that the Emissions Limits would not be passed in the test. The concept of the DD is not about what happens in the test (that notion is only brought back by the Article 5(2)(c) ER test inclusion provision), the Emissions Limits do not apply outside the test where the DD operates, and there is

no basis for reading "effectiveness" as meaning "*leading to passing the test if the settings are applied during the test"*.

The Absolute NOx Approach (SCR only)

587. The fifth comparator (specific to SCR systems) is known as the Absolute NOx Approach. In other words: "*There is no reduction in effectiveness if it can be shown that the absolute amount of NOx converted by the SCR system (if present) per km on average when the vehicle is driven outside Test Conditions is no lower, and may even be higher, than the Absolute NOx Conversion when the vehicle is driven inside Test Conditions*".

588. This approach is one answer to the question posed above of how SCR efficiency can be tested, given that correlation to dosing is a false approach. The essential premise underlying this approach is that if the SCR in the NEDC converts a certain amount of NOx per km on average, and the vehicle's NOx emissions remain under the limit permitted per km on average in order to pass the test, then it stands to reason that if the amount of NOx converted per km on average on the road is the same or higher (i.e. is no lower) than the amount converted during the test, there is no reduction in the effectiveness of the SCR. The SCR is converting the same amount of NOx or more: its effectiveness is not reduced.

589. The Claimants reject this as an after the event justification for the throttling of AdBlue consumption. They also contend that the comparator is wrong because a reduction in effectiveness has to consider the potential effectiveness of the SCR in terms of its ability to reduce the NOx actually presented to it. So, a manufacturer is wrong to argue that if they remove, say 2 grammes of NOx in the NEDC, over 20 minutes and 11km, any system that reduces 2 grammes of NOx over a similar distance/time is equally effective and there is no reduction in effectiveness: the reduction in effectiveness condition has to compare the capability of the system and the potential NOx conversion rate. As a result, anything that alters the target efficiency is a defeat device.

590. This dispute is a highly significant one – affecting a number of manufacturers. Ultimately I come to the conclusion that the Claimants are right to this extent: the Absolute NOx Approach is not an accurate way to measure effectiveness of the SCR for a variety of reasons. One is that a wealth of material demonstrated how different was the real life calibration compared to that deployed in the NEDC. However, at the same time this is an artificial situation. The calibrations were not developed to affect NOx production; the relevant calibrations used in the NEDC test are essentially ones which were developed in order to demonstrate the working of the SCR in a test which was not particularly apt to it. They were not used or intended to operate in real life. And because of the way the NEDC was structured the SCR was warming up and not operating remotely as it would in real driving conditions.

591. Another issue is that at least some of the manufacturers themselves analysed efficiencies in a way which was diametrically opposed to the Absolute NOx Approach.

592. A real concern is that the Absolute NOx Approach would effectively provide a poor comparator: the averaging of NOx conversion in a short drive cycle is a particularly flawed approach for SCR, because the SCR will not work until the system has reached a certain "light off" temperature, and it is more effective once it has fully warmed up. But

the warm up period forms part of the average figure PCD and Mercedes rely upon, thereby artificially lowering the average that is then used as the comparator.

593. Thus if the manufacturers were right about this approach the average NOx conversion required to pass the gentle, low load NEDC cycle would become the benchmark for NOx conversion in any other circumstances, including much load driving that produces higher NOx. That would severely limit the effectiveness of the scheme laid down by the ER, because it would permit a strategy that cannot respond to or compensate for increased engine-out NOx from driving up a hill or at altitude or at cold temperatures.

594. Also in the Claimants' favour is the absence of any textual "steer" towards such a test in the ER's wording. I would not decide this issue on this point alone – because SCR was a developing technology which almost certainly was not in the minds of the drafters.

595. At the same time some of the Claimants' arguments in favour of rejection of the Absolute NOx Approach are wrong. The attractive headline: "*it can't be right because if it were it would mean it is OK not to dose for 30 minutes (a point directed to PCD)*" was demonstrated by Mr Cutress KC to be a false point as well as a new one: on the actual CSVs other than one test for PCDC3 in which the period was 15 minutes, the next longest period for that vehicle was 5 minutes..

596. Further, isolating the issues with the Absolute NOx Approach does not provide a solution to how to test for SCR effectiveness. As noted above, the tailpipe approach which the Claimants overtly advocate is impractical. That is doubtless why they tend to revert to a correlation (which they have accepted is false) between dosing and effectiveness.

597. The best way which the parties have been able to find of reflecting any assessment of SCR efficiency is either the Absolute NOx Approach or the Percentage NOx Conversion Approach. The latter would seem to be much the better approach, in the light of the issues reflected above; indeed both Mercedes and the Claimants seem tacitly to accept its merits (albeit that they each advocate another approach as their primary approach). But this approach too then faces the not inconsiderable problems that (i) it is more difficult to ascertain the necessary figures and (ii) efficiency will necessarily vary (e.g. when the SCR is warming up). A blended average is meaningless unless the circumstances in two tests are essentially the same; the alternative leads back to a "julienning" approach which is inconsistent with the way the test is conducted.

598. The result here is that Absolute NOx is plainly not a robust way of testing SCR efficiency; but nor is any other (workable) means of testing. There is no satisfactory way of empirically testing SCR efficiency in operation. The issues which this approach engages gives another example of the very great difficulties which arise if reduction in effectiveness has to form an empirical part of the test.

<u>Legal Issue 3 and the significance of cycle recognition</u>

599. This brings the outline back to the disjunction alluded to at the start of this section. The Claimants contend that the correct construction of the relevant provisions involves all of the above steps (taking out irrelevant comparators once comparators are decided upon). For most of the Defendants however this is an approach which fails to see the wood for the trees. For them the definition at Article 3(10) is one which aims squarely at defeat/cheat/manipulation. This different approach is (possibly imperfectly) captured in

PDD Legal Issue 3 which is: "*For a defeat device to be found, does there need to be an intentional and/or impermissible purpose of causing the ECS to operate differently when it senses it is being tested?*"

600. Mercedes and other Defendants submit that the only definition of a DD that is (i) coherent and (ii) does not infringe the principle of legal certainty, is one in which a DD must, objectively viewed, operate with the intentional and/or impermissible purpose of causing the ECS to operate differently when it senses that it is being subjected to a test cycle compared to when it does not sense that it is being subjected to a test cycle.

601. The Claimants submit (see further below) that this argument is little short of outrageous, that it is contrary to authority and that it gives insufficient weight to the critical word "defeat". The Claimants also rely upon the fact that not all of the manufacturers wholeheartedly supported this case in opening.

Analysis

602. A huge amount of argument was directed to this point, which can only inadequately be reflected below. What follows must be read in the light of the introduction given above as parts of that section are relevant both as to the core approach to interpretation and to the question of sense/cross checks.

The approach to interpretation

603. The correct approach is vital. The Claimants were emphatic that the approach to questions of interpretation must be squarely grounded in the approach under EU Law. In *CLCV* at [62] the Court stated them in this way:

> "In that connection, according to the settled case-law of the Court, the meaning and scope of terms for which EU law provides no definition must be determined by reference to their usual meaning in everyday language, while account is also taken of the context in which they occur and the purposes of the rules of which they form part (judgment of 1 October 2020, Entoma, C-526/19, EU:C:2020:769, paragraph 29)"

604. This approach (which as Waksman J noted in *Crossley 2* is *"more obviously purposive than a similar exercise in the UK"*) is not disputed; however the Defendants also remind me of the importance of legal certainty:

    i) Generally: "*[T]his fundamental principle of EU law requires, in particular, that rules should be clear and precise, so that individuals may ascertain unequivocally what their rights and obligations are and may take steps accordingly*." *R (PJSC Rosneft Oil Co) v HM Treasury Case C-72/15 EU:C:2016:381 at §161; Denmark v Commission Case C-348/85 at §19; Vleeswarenbedrijf Roermond BV and others v Produktschap voor Vee en Vlees Case C-354-356/88*;

    ii) Particularly: in the context of giving weight to the travaux of the ER/IR citing: Denkavit Internationaal v Bundesamt für Finanzen Joined Cases C-283/94, C-291/94 & C-292/94, [1996] ECR I-5063, at §§28-29; AG Kokott's opinion in Criminal Proceedings against Taricco Case C-105/14 [2016] 1 CMLR 21, §§92-105.

605. I have also borne in mind the useful summary of the approach to interpretation of EU legislation in *Crossley 2* at paragraphs [170-176].

The relevance of prior authority

606. Before considering the matter further it is right to note that the Claimants contend that the Court need not proceed from a standing start in that (i) the meaning of "defeat device" has already been considered by the English Courts in *Crossley 1* (ii) the test of intentional and impermissible purpose is contrary to CJEU authority – specifically as regards thermal windows in *GSMB, DUH* and *QB*.

607. However, as the passages above make clear, the Claimants' reliance on the authorities is over stretched. As for the *Crossley* point, it will be recalled that on the facts there the device was on any analysis a CRDD, and the relevant passage occurred in the context of an entirely different argument to the one advanced here – in that there the Claimants were advancing an argument that the word defeat had to correlate to defeat of the test. It is not ratio – it occurs in the context of a paragraph which commences "*I interpose here to say something about the word 'defeat'*".

608. As for the EU authorities, as explained earlier, the only one which is binding is *CLCV*. That again deals with an obvious CRDD. In large part it takes matters no further being largely addressed to a device which has the ECS on in test and either off or operating far different out of test and issues which are very different to those here. What can be taken from it in this regard is very much in issue.

609. The Claimants say that *CLCV* establishes that the notion of a "defeat device" is to be read broadly, since its purpose in essence is to prevent the goals of the ER, namely reduced real-world NOx emissions from passenger vehicles, being subverted. Particular reliance was placed on Recitals 1 (harmonising type approval), 4 (limiting tailpipe emissions during the normal life of a vehicle under normal conditions of use), 5 (need to meet air quality objectives) and 6 (considerable reduction in NOx emissions needed to improve air quality), and as embodied in Article 4 the objective of the ER is to reduce NOx emissions *"throughout the normal life of vehicles under normal conditions of use"(CLCV,* [88]*)* and thereby improve air quality and to ensure a high level of environmental protection and improve air quality.

610. Overall while I can see how that appears correct to the Claimants, the reading of *CLCV* which commends itself to me is that advanced by the Defendants – and in particular by Ms Howard KC in closing. As she submitted, given the context in which the decision is given, the best reading of *CLCV* is that the ratio is clearly delineated to prohibit devices which are systematically programmed not just to mirror the NEDC test conditions or their nearby comparables but to use them as the basis for artificially adjusting the performance of the ECS in those conditions in order to pass the test. That can be seen in particular at:

    i) [39] " *the vehicles concerned were fitted with a device which detected the approval procedure, modified the operation of the exhaust gas recirculation system for the purposes of that approval, and reduced NOx emissions for the purposes of that procedure. ... the emission control systems of those vehicles had been manipulated in order to increase the opening of the EGR valve when an approval phase was detected."*

ii) [98]: "*the introduction of a mechanism the sole purpose of which is to ensure compliance with the emission limits ... only at the type approval phase would run counter to the obligation to ensure that emissions are effectively limited under normal conditions of vehicle use.*"

iii) [115] "*Article 5(2)(a) of Regulation No 715/2007 must be interpreted as meaning that a defeat device, such as that at issue in the main proceedings, which systematically improves the performance of the emission control system of vehicles during type-approval procedures in order to comply with the emission limits laid down by that regulation, and thus obtain the approval of those vehicles, cannot fall within the scope of the exception...*"

iv) AG Sharpston [127] "*a device which detects any parameter ..., for the purposes of activating or modulating upwards, during those procedures, the operation of any part of the emission control system, and thus obtaining approval of the vehicle, constitutes a 'defeat device' within the meaning of that article, even if upward modulation of the operation of that emission control system may also occur from time to time when the exact conditions that trigger it occur by chance under normal vehicle operating conditions.*"

In other words *CLCV* either favours the CRDD analysis or goes no further than CRDDs.

611. So far as the other cases are concerned, I accept the submission that (i) they are not binding and (ii) while they should be carefully considered, they should not constrain my approach, even as regards thermal windows. My reason for reaching this conclusion is that while they are not binding, I would certainly be very hesitant to refuse to follow them had the evidence base and issues before the courts in question been similar to those which are available to me. However, this is the first case in which detailed expert evidence as to the functioning of diesel engines has been before the court and it is quite plain from the reports of the cases that this court has had much fuller and more detailed argument addressed to it than did any of those courts. For example, in *GSMB* it appears to have been assumed that because the EGR rate decreased linearly as temperature changes, this amounted to a PDD. There was no detailed consideration of the reasons for the decrease in EGR rate, whether it was a decrease down to zero which was objectionable or whether linearity was itself seen as problematic. Further, as noted elsewhere almost entirely without exception those cases actually concerned devices which fell squarely within the ambit of the CRDD definition.

<u>*Literal interpretation and context in the rules*</u>

612. It is fair to say that the literal meaning of Article 3(10) alone is unlikely to be dispositive in this case. However taking the question of literal meaning first, the "take away" on this level is all about how fast one reads (or physically transcribes) the text, what emphasis is placed on which words – and what pauses one takes along the way.

613. Thus, an initial, fast, reading almost inevitably favours the Claimants' approach. Having now read the relevant definition[8] more times than I can recall, my own impression is that

[8] For ease of reference with illustrative shading:

the definitional indigestibility of the passage which runs from half way through the first line to half way through the fourth line, blurs the impressions of the first part of the definition and throws emphasis on the comparative clarity of the latter few lines. There is a tendency to read: *"any element of design … that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use."* That does not do full justice to the language and collapses the definition into that of "*reduction in effectiveness"* and "*normal driving conditions"*.

614. In truth however, literal meaning requires us to give weight to the entirety of the (we know) carefully considered wording.

615. It is therefore important to note some of the parts which get lost in a fast read. The literal meaning should give weight (or at least acknowledgement) to the fact that under Article 3(10) ER, the "*element of design"* which defines a DD must:

    i) "*[S]ense*" a parameter;

    ii) "*for the purpose of activating, modulating, delaying or deactivating the operation of any part of the ECS*", that;

    iii) "*reduces the effectiveness of the ECS*";

    iv) "*under conditions which may reasonably be expected to be encountered in normal vehicle operation and use*".

616. In essence, what these words say is that a bit of the engine (a design element) must sense something and make the ECS behave differently in real life. Matters are not helped by the fact that the definition, despite its plethora of words, omits key points:

    i) The combination of "*senses*" with (paraphrasing) behaves differently in real life asks: differently than what?

    ii) To this the only answer can be: differently to in the test, giving a test/non-test disjunction;

    iii) This logically means that these words say that the element of design must:

        a) sense the difference between in test and out of test (i.e. must sense the vehicle is being tested); and

        b) cause the ECS to behave differently in consequence.

    iv) Objectively considered, an impermissible change of behaviour resulting from the detection of the test is what is required.

"'defeat device' means any element of design which senses temperature, vehicle speed, engine speed (RPM), transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use"

617. These textual "tells" or "anchors" do in my judgment point – albeit in a preliminary way – towards an intention to outlaw only CRDDs; that the element of design must **sense** a parameter **for the purpose** of activating (etc.) the ECS, implies a positive action taken with a specific aim. If intention were to be irrelevant it would be more sensible to use *"to activate*" or "*activates*". In this context it is perhaps telling to go back to the formulation of the question and answer in *CLCV*.

618. These are not the only textual indicators pointing in this direction. Mercedes relies upon a read across from different language versions of the regulations on the basis that as a matter of EU law, different language versions of the ER are all equally authentic and "*[a]n interpretation of a provision of Community law thus involves a comparison of the different language versions*":

    i) In some language versions of the ER, the definition of a DD translates into English as a manipulation device a wording which is redolent of intentional and impermissible change. Examples are the Danish "*Manipulationsanordning",* Dutch *"manipulatie-instrument"* and Romanian *"Dispozitiv de manipulare*");

    ii) Other language versions adopted terms which translate into English as nullification or rendering inoperative, consistent with requiring a change to the behaviour of the ECS. Examples here are Spanish "*dispositivo de desactivación*"), device that automatically switches off (German "*Abschaltvorrichtung*"), discontinuance (Greek "διατάξεων διακοπής της λειτουργίας"), neutralising / deactivating (Hungarian "*hatástalanító berendezés*").

619. While the Claimants rightly point out that still further translations do not resonate similarly, using more neutral terms equating to "*deactivation*" or "*suspension*", that use of language in regulatory text is of some limited weight. (And while not part of the analysis here it is interesting and will be referred to by way of cross-check that the Euro 7 approach specifically talks about *"manipulation strategies"* and *"manipulation devices"*.)

620. Overall, therefore I conclude that on the language of Article 3(10) itself the preliminary balance falls towards the CRDD interpretation, with a small further weight given by the balance of the other textual versions.

621. I would also note here, though it might not be said to be fully a literal interpretation point, that a consideration of the issues to be decided later under Article 5(2) and the argument as to burden of proof under that Article provide another indication which favours this approach. The conventional approach to exceptions is for narrow construction and the burden to be on the person relying on them; that makes perfect sense, and is a good and harmonious fit with the CRDD approach to Article 3(10). However, if a much broader reading of Article 3(10) is adopted there is a tension with an approach which requires minimal derogations from that and the burden on the defendant becomes difficult to accept as intended (see above regarding the logical outcome of the Claimants' case).

622. This overarching point on literal interpretation is consistent with the English law approach to construction (for example classically in *Barton v Fitzgerald* (1812) 15 East 530 or more recently in *Re Sigma Finance* [2010] All ER 571); and it is equally consistent with the EU authorities (see for example para 668 of "*Judicial Control in the EU: Procedures and Principles*" by Lasok and Millett (1st Edition, 2004)). The two

provisions have to be construed together so as to produce an overall result that makes sense of the prohibition as a whole in its regulatory context and given the various concerns set out in the recitals. Taking the two provisions together the CRDD construction clearly works better across the two.

The context and purpose

623. There is a wide variety of context and purpose arguments which could be considered here. The questions of context and purpose might be taken separately, but in this case there is often a question about whether a contextual point feeds into purpose. Thus it makes sense to take both together.

624. Purpose was a major issue between the parties, reverted to repeatedly in the course of argument. Again, the arguments divided sharply with each side contending that the evidence on purpose and context favoured their own interpretation of the ER.

625. For the Claimants the purpose of the rules was simple: the reduction of emissions and improvement of air quality, for all the very good environmental and health reasons set out in the documents leading to the regulation, and the ER itself. For the Claimants that is effectively the sole purpose, and it drives a broad interpretation of the definition and a strict approach to exceptions.

626. For the Defendants, it is accepted that the Claimants' argument is correct at a high level. But it is incomplete because it fails to recognise the competing demands that arise and the other aims that are also pursued. They point to the wider objectives of the ER including competitiveness, cost innovation and the need to regulate other pollutants at the same time. The overall purpose of the ER is therefore to incentivise and enforce new emissions standards to improve air quality, while taking into account the capital-intensive research and development that would be needed, in relation to which it was recognised to be critical that the additional costs of meeting those emissions targets were not to be such as to deter consumers from purchasing diesel vehicles, whilst providing legal certainty for manufacturers and clarity as to the expectations placed on them by the prescription of clearly defined and definitive tests. The Defendants, therefore, say that the prohibition on DDs must be construed consistently with its being part of that overall scheme.

627. On this purpose argument it seems quite clear that the primary purpose of the ER is as the Claimants stated, but that whether one regards them as secondary purposes, modifications to the primary purpose or important contextual matters, the matters on which the Defendants rely form an important part of the picture.

628. In this respect, as noted above:

    i) The EU TA legislation (of which the ER forms a part) is the result of a series of EU-specific policies and targets on inter alia safety, NOx, CO_2 and other regulated emissions. Recital (20) ER records the purpose of the ER as a consolidating measure;

    ii) The ER is explicit that the improvement of air quality will create a particular strain on manufacturers, who will require long lead times to develop technologies and implement them in mass production. The ER also requires manufacturers to

develop diesel engines that comply with ambitious limit values for a number of pollutants at once, and acknowledges the technical challenge in such a requirement;

iii) One key objective of the EU legislation was to encourage the EU public to buy diesel vehicles, something which would be unlikely if the implications of the ER were either a large increase in cost or a selection of vehicles which were unattractive to drive;

iv) One purpose of the ER is to provide clarity for manufacturers, something it explicitly prioritises.

629. Both sides urged contextual points upon me, and I have borne them all in mind.

630. The ones which in my judgment require to be highlighted are as follows (the context within the Regulation having been dealt with above).

631. The first is the wider context in which the ER exists. Here, the Defendants highlighted the fact that this regulation sits within a timeline of emissions regulations wherein there was deliberate and intentional staggered implementation of emissions limits over a period of time. Thus far the context is unarguable. From here, the argument progressed into a consideration of the extent to which the *travaux* were admissible, in particular in relation to the Defendants' cherished citation of the "*precarious balance*" wording. On this the Claimants contended that the *travaux* fell outside the ambit of the authorities in that the relevant part of the *travaux* was not *"bang on point"*, being rather the casual words of the committee and not the common intention.

632. On this debate it seems to me that there is a danger of overburdening the argument. Overall, the best statement of the relevant context (as perceived at the time) is to be found in the recitals. Those statements clearly represent not the working, but the final agreed position as to backdrop. Those recitals have been given at length in the Key Provisions section above, but acknowledge both aspiration and complexity. There is aspiration (and indeed determination) to achieve reductions in emissions, and to levels which represent a challenge. However, there is also implicit acknowledgement of the potential impacts on other emissions, on hydrocarbon extraction levels (as a knock on from impacts on fuel efficiency) and the economic impact, both for purchasers and for manufacturers.

633. One aspect of the timeline and the planning which is in my judgment important context is that the Euro 5 standard was seen as a starting point, a precursor to more demanding limits, and a precursor to more sophisticated testing. This is significant both in assessing what was intended to be achieved in 2015 as opposed to 2017, or 2019 – in other words it would be surprising if the meaning of the Regulation meant that at this stage the bar were set higher than it was to be later; and also is flagging (as recital (6) expressly does) the importance of certainty and planning security.

634. It is quite clear that this was a first measure with further regulations to come in gradually. This would lead to a question whether the right construction means that the ER imposed NOx requirements covering nearly all possible conditions of use or to impose regulations which would be more strict than those which were to come. On the other hand, some of the sting goes out of the Claimants' case that the CRDD approach is too narrow, if one bears in mind that it was plainly contemplated at the time of drafting the ER that the testing regime would expand and become more demanding. A narrow definition of defeat

device in the context of a fairly undemanding test may look unattractive; but that same approach is less so when the test is much wider and more demanding (and a proper proxy for NDC). In a sense, there becomes no logic in the Claimants' approach of regarding NDC as "other" to the test if the test really approximates well to real life driving.

635. At this preliminary point (and taking a narrow approach to the admissible contextual evidence) the weight of the arguments inclines fairly firmly towards the CRDD approach.

Practical implications: context or cross check

636. One area which might legitimately be regarded as context is that of the practical implications of the competing constructions. And if not properly to be regarded as admissible contextual evidence, this is certainly a matter which can form a legitimate sense check, not least bearing in mind the requirements of legal certainty and the need for parties to know what their rights and obligations are especially where serious sanctions are available.

637. The practical implications of the competing approaches lend, in my view, very considerable support to the CRDD approach. The first aspect for the Claimants' approach is the difficulty of drawing a line short of a place which, judged against the relevant background, must be absurd. The logic of the Claimants' case leads them to say that any change in calibration is a DD, and that then leads to a position where, despite accepting that the Emissions Limits do not apply out of test, contending that they in effect do – and that they apply in far more extreme conditions than the test itself imposes. The Claimants' case leads to the example given in the opening of this judgment – and to circumstances where the later (intended to be stricter) iteration of the rules would be no such thing.

638. As has already been noted, the Claimants' approach to this issue has been somewhat protean, probably in part because the implications of the way in which they put their case lead to these impossible points.

639. The second aspect is the practicality of proving this case. The need to unpick individual calibrations, to conduct complex road tests on ornate counterfactuals with software and engineering experts. The need to grapple with a multitude of questions about how when and why people drive across Europe. The need either to say RIE is proved via a desktop analysis (which does not or may well not match the realities on testing) or to construct a way to measure RIE when no route of so doing is robust and most of them are obviously flawed. These are alluded to above, and will be seen again on repeated occasions as the individual alleged defeat devices are considered. There are other practical issues too. For example, how can a literal and empirical approach to RIE deal with a situation where a device (say EGR) is derated, but at the same time another device (say SCR) kicks in? In the end, the practical implications of the Claimants' case are so far from promoting certainty that they suggest powerfully that the CRDD approach is right.

640. That is not to say that the CRDD approach is without its own problems.

641. I bear in mind the potential for the CRDD approach to create puzzles within Article 5(2). Those relate to the scope left for Articles 5(2)(a) and (c) - and whether if the CRDD approach is taken, they become redundant. How, for example could a device which is designed to defeat the test ever be justified? The answer is that the exception may be very narrow indeed (particularly at the stage of the NEDC test as opposed to the RDE or

WLTP), but it is still conceptually there. So for example, by the time one has the wider RDE boundaries, there may be instances where a device is needed to prevent a high risk of combustion failure or burnout. Similarly for Article 5(2)(c) this may apply to an element of design that reduces the effectiveness of the ECS where it recognises parts of the NEDC and goes in to "off" mode, but during some other parts of the NEDC it is in "on" mode. Such a device is a DD: it is a test cycle recognition device because it is in "off" mode during parts of the NEDC (even though it is not in "off" mode across the NEDC). However, if it is "substantially" in "on" mode (modulating so as to reduce the effectiveness of the ECS) during the NEDC then its effect on NOx emissions will be included in the NEDC and there is no need to prohibit it.

642. The more significant point made by the Claimants is that of whether, if this argument were correct, there could be effective enforcement of devices that do not operate exactly to the cycle but in truth operate entirely at odds with the purpose of the emissions legislation.

643. This is in my judgment a strong point and it is the reason why the "pure" cycle recognition argument as expressed by Mercedes cannot be right. There is great force in the argument that assuming the CRDD approach is broadly right, what the overall thrust of Article 3(10) is trying to outlaw is "defeat" or "cheat" (or in later terminology "manipulation") strategies, and that the comparison which the regulation is aiming at is not the granular and complex exercise by reference to expert evidence we have engaged in, but rather something designed to ensure that the "set up" of the engine for the test is essentially the same as that which will be in day to day use.

644. Thus to confine it to pure, exact cycle recognition would be to invite manufacturers to cheat by recognising not the cycle itself but the foothills of the test – to ensure that nothing is triggered by the test itself, because it is triggered by a slightly wider thermal window, or by a set of parameters which contains the outline of the first part of the NEDC, and some extra circumstances, but which is something you would not do if you simply wanted the engine to perform well for NOx and other parameters while being safe.

645. This is what takes Ford to their "*boundary device*" approach, which was urged in opening but taken very quietly in closing. In large measure I agree with that approach. However, the mere fact that a device operates on a boundary does not make it a defeat device, because there may well be circumstances in which there is a calibration or device working at a boundary which operates not for the purposes of cheating, but for some other perfectly legitimate reason. Calibration by reference to a boundary as a rough starting point may be an example. The question of the purpose will usually be significant.

646. A boundary device therefore is a covert CRDD – it is calibrated to not detect the test itself but to ensure the device is on by the time you get to the test. It will be recognisable by two hallmarks: (i) calibration to near test boundaries/parameters (ii) no good reason to start at that point.

647. This obviously leads into questions about the permissibility of "optimisation" which was a major theme between Ford and some of the other manufacturers on the one part and the Claimants on the other. For the Claimants any optimisation is a defeat device – regardless of how well the engine would have worked without it. Ford's submission was that there is nothing wrong with optimisation – drawing an analogy with job applications. As Ford

see it, if a job is advertised as requiring certain criteria to be fulfilled, there is nothing wrong in providing the strongest possible answer. There is nothing wrong with "*best foot forward*" - provided there is no manipulation or artificial distortion that disguises the true performance of the ECS.

648. Where such a device is pure optimisation (i.e. improvement above something which would pass the NEDC (which it must be recalled was the only obligatory standard) that is not cheating and does not fall foul of the test in the regulations. At the same time "optimisation" is obviously a high-risk strategy once it provokes this kind of debate – the fact that there is a degree of tweaking which relates to performance under test conditions opens a manufacturer up to the defeat device argument. The debate will be vibrant about cases where the calibration is optimised to pass the test, it operates in the same way on the road, but does not work very well on the road.

649. Here Ford's other answer illustrates the danger. Ford says that there is nothing wrong with optimisation so long as the engine would pass the test without the optimisation. In the CRDD analysis that, in my view, is correct sometimes, but cannot be stated to be axiomatically correct. The optimisation may indicate an intent to have a differential performance for the purposes of passing the test. If it is known, up front, that the non-optimised or default calibration would pass the test there is no defeat or cheat involved in the optimisation. Fairly obviously the sub-text in such optimisation is to allow the manufacturer to advertise just how very well the vehicle performs on NOx emissions in the test, in order to win the market over the other manufacturers. But what if no thought is given to passing the test with the non-optimised version, there is calibration correspondence about how to ensure "optimised test mode" passes the test and it is only an ex *post facto* testing regime which suggests that the non-optimised version would in fact have passed the test?

650. Much attention was devoted at trial to calibrations which sensed not the test but preconditioning, and which then ensured the vehicle presented at the start of the test in optimum form. The key examples here were the LNT preconditioning purges. This will be dealt with further below. In broad terms, and consistently with the majority of the expert evidence, I conclude that a calibration for preconditioning to ensure purging in advance of the test is not *per se* offensive. That is because it goes to ensuring the robustness of the test – it is not designed to defeat the test, but to ensure replicable results in a context where results are vitally important (as can be seen from the preconditioning soak, etc). Professor Tunestål accepted that with an LNT one would never know the capacity (by which he meant, in context, the state of loading) in any given vehicle at any given time. Therefore, the way to be certain of a constant initial condition for all vehicles to be subject to standardised testing was to reduce the initial LNT NOx load to zero.

Further cross checks

651. Further support for this modified CRDD approach can be gleaned from other passages in the supporting material for the ER:

    i) The prohibition itself appears in "*Chapter II: Manufacturers' type-approval obligations*", in Article 5 ER, headed "*Requirements and tests*". As is evident from the title of the section in which it appears, the prohibition was intended to form part of manufacturers' obligations in relation to the testing of vehicles for TA. At its core, the prohibition requires manufacturers not to attempt to manipulate the

requirement of testing by submitting for testing vehicles that sense the occurrence of the test and behave differently when the test is so sensed;

ii) As already noted, the primary purpose of the regulation was to improve air quality by a rigorous emissions testing TA scheme while maintaining the "*precarious balance*" such that the extra cost or delay in designing new diesel vehicles is "*not so great that consumers will either opt for petrol cars (which would have an adverse impact on emissions of CO_2 and fuel consumption) or prefer second-hand cars*";

iii) That the legislature intended the definition of DD to have an intentional and/or impermissible purpose at its core was confirmed by the European Parliament Rapporteur Mr Bernd Lange (as noted above) and this is also the approach which appears to be indicated by the EP Committee draft report (COM(96)0248 - C4-0463/96 and COM(97)0077 - C4-0091/97 - 96/0164(COD)) Explanatory Statement, also cited above.

652. While the Claimants also point to background in favour of their arguments (e.g. the genesis of the term defeat device from the US regulatory environment) it is clear that that background involved "cheat" devices being the focus. As noted above in the early 1990s six manufacturers of trucks in the USA were found to have used software to recognise the test cycle and adjust emissions behaviour accordingly in order to circumvent EPA requirements. The mischief which was in the originating drafters' minds was test recognition and cheating. Where the approach in the US has gone from the origins cannot be taken as particularly significant when everyone agrees that the US approach was noticeably different, and conducted against a different economic background as regards fuel consumption sensitivities (acute in the EU market, tangential in the US).

653. As already noted in passing, the Mercedes/Ford submission is also consistent with the approach of the subsequent legislation, where the terminology has changed from "defeat device" to "manipulation device": Regulation 2024/1257 which repeals and replaces Regulation 715/2007 provides instead:

> "5. Manufacturers shall not design, construct and assemble vehicles with manipulation devices or manipulation strategies.
>
> 3. (41) "manipulation device" means any element of design that results in a vehicle not complying with the requirements of this Regulation when driven but not under a regulatory test, despite it resulting in the vehicle appearing to be compliant when tested, or that manipulates data related to sensors, fuel or electric energy consumption, electric range or battery durability;
>
> (42) "manipulation strategy" means a strategy that results in a vehicle not complying with the requirements of this Regulation when driven but not under regulatory test, despite it resulting in the vehicle appearing to be compliant when tested, or that manipulates data related to sensors, fuel or electric energy consumption, electric range or battery durability;"

654. The associated Guidance appears also to refer back to the prior regulation as being in the same tradition:

> "(26) Achieving the Union air quality objectives requires a continuous effort to reduce emissions from vehicles. The use of manipulation devices as well as manipulation strategies should be prohibited under this Regulation. That prohibition is essential to safeguard those objectives. When assessing situations that could involve the use of manipulation devices or manipulation strategies, a broad assessment and interpretation of those situations should be made, in line with the case law of the Court of Justice of the European Union on defeat devices in the context of Regulation (EC) No 715/2007. Any devices or strategies that reduce the effectiveness of exhaust and non-exhaust emission limits and testing condition requirements under this Regulation, that cause a non-compliant vehicle to appear compliant or that falsify test results, should be taken into account when determining whether manipulation devices or manipulation strategies exist. Designing, constructing and assembling vehicles with such manipulation devices or manipulation strategies should be subject to penalties."

655. Similarly, Regulation 2016/427 which introduced RDE testing introduced a new provision in relation to defeat devices, specifying that detection of the collection of ECU data would be considered a defeat device. Regulation 2016/427, Annex IIIA, para 4.4 provides: "*If for a vehicle the collection of ECU data influences the vehicle's emissions or performance the entire PEMS test family to which the vehicle belongs as defined in Appendix 7 shall be considered as non-compliant. Such functionality shall be considered as a 'defeat device' as defined in Article 3(10) of Regulation (EC) 715/2007*". Plainly this was a provision directed at "sensing" the test.

656. The legislative background is not all one way of course. The Claimants also rely upon the Guidance from 2017 which identifies the types of AES that might require further investigation, and notes that these would not be problematic if Mercedes was right about CRDDs. However the balance of background material is very much in favour of the CRDD approach, and this last point does represent a development of the way of assessing issues following the identification of some of the problems inherent in a non-CRDD approach. an *ex post facto* approach in guidance (i) cannot drive a conclusion as to the correct construction of an earlier provision and (ii) might in any event be wrong (as has occurred in the context of Russian sanctions guidance).

Conclusion: interpretation of the definition

657. It follows that in my judgment the answer to the primary issue on the interpretation of Article 3(10) is that on its true construction it is directed only to devices which operate with the intentional and/or impermissible purpose of causing the ECS to operate differently when it senses the test cycle or its boundaries compared to when it does not sense the test cycle or its boundaries.

658. This is a conclusion which is close to the Mercedes approach but qualified so as to bring within the ambit of CRDDs devices which are in essence designed to evade/cheat the Mercedes definition.

659. This is a conclusion which is a considerable way from the Claimants' case; however it is to be noted that it captures the "cheat" element which has been so large a feature of their argument. The Claimants' approach involves too partial a focus in the start and finish of the provision, neglecting the importance of sensing and purpose. It involves too blinkered

an approach to purpose, ignoring a lot of important wider purpose and context. It is unrealistic and impractical: it equates in reality to saying that any parameter that produces any reduction (however small) in the EGR rate outside the NEDC necessarily constitutes a RIE. Such an approach is in tension with the Claimants' own acceptance that some modulations of the EGR rate are necessary to maintain combustion and hence do not constitute a DD.

660. The Claimants' overall construction falls foul of the need to look holistically against the wider wording of the ER and what that involves and the real world context: it renders unlawful any modulation of the ECS that (in the Claimants' view) renders its operation less efficient outside the NEDC than in the NEDC for any period of time, regardless of any impermissible purpose, save only if one of the narrowly defined Art.5(2) ER exceptions can be satisfied. Given the potential criminal penalties that may be imposed in respect of DDs, it is unrealistic to suggest that the purpose of the ER was to penalise modulations (including minor modulations on the Claimants' case) of the ECS devoid of any impermissible purpose. Ironically also the Claimants' approach forces them to prove reduction in effectiveness – and creates practical problems for them in proving their case – as the detailed consideration of the alleged defeat devices will demonstrate.

661. To bring it back closer to the wording of the regulation I conclude that:

A defeat device is a device which senses one or more parameters of the test (including its boundary) and objectively operates with the purpose of causing the ECS to work more effectively when it senses that it is being subjected to a test cycle compared to how it works in out-of-test driving.

Article 5(2) issues

662. The backdrop to the interpretation issues here must include the binding decision in *CLCV* that Article 5(2) ER exceptions are to be interpreted strictly so that the general prohibition of DDs is not negated and so that the ER's purpose can be effectively discharged. Additionally, the interpretation of exceptions may not go beyond the cases explicitly envisaged by the ER, meaning that assessment of the Article 5(2)(a) to (c) exceptions themselves is a narrow one.

663. The Defendants (specifically Mercedes) would nuance this by reference to *OFT v Abbey National* [2010] 1 AC 696 and its reference to "*specific interests that the relevant exception…is designed to protect. Such an exercise might involve reading words in, cutting them out or taking any other step necessary to produce a result which reflects the relevant purpose in the circumstances*". However, that provides nothing which is really in tension with this starting point: exceptions are read narrowly but in a way that safeguards the utility of the exception whilst also ensuring that the relevant purpose of the legislation is met.

664. One important dividing line here is again the question of purpose. The Claimants say that the purpose of the ER is to ensure a high level of environmental protection and improve air quality within the EU. The Defendants contend, and I have substantially accepted that while that is the primary purpose, the ER regime also has subsidiary purposes. Of course it is true that one purpose of the ER is environmental protection and the improvement of air quality in Europe. But, as set out above, the ER is explicit in many places about the balance involved. To give but one example: "*(6) In particular, a*

considerable reduction in nitrogen oxide emissions from diesel vehicles is necessary to improve air quality and comply with limit values for pollution. This requires reaching ambitious limit values at the Euro 6 stage without being obliged to forego the advantages of diesel engines in terms of fuel consumption and hydrocarbon and carbon monoxide emissions." Indeed at (7) of the ER the implications for markets come first, before the benefits that accrue in terms of air quality.

665. That set of co-operating purposes needs to be borne in mind when turning to the interpretation of Article 5(2).

PDD Legal Issue 5: Burden of proof

666. The burden of proof argument has loomed large over the litigation. All Lead Defendants (save Ford) assert that, because it is an essential part of the Claimants' case that any DDs are PDDs, the Claimants bear the burden of proving that any DDs fall outside Article 5(2)(a)-(c). Ford accepts that the Defendants have the burden of producing a case that one or more of the Article 5(2) justifications are *prima facie* engaged, but argues that, thereafter, the Claimants have the burden of rebutting that case.

667. This was a characteristic piece of realism from the Ford team and a sensible concession. Indeed given the view I have already taken on the meaning of Article 3(10) it is inevitable that the burden of escaping its toils must fall on the Defendants. The evidential and legal burden falls on the Defendants who assert that they can bring themselves into this statutory exception to the prohibition on DDs.

668. Given the structure of the relevant provisions (and on the basis of the CRDD approach which I have preferred), where the two elements are very distinct it is not fair to say, as Mercedes does, that the exercise involves proving the existence of (i) a DD within Article 3(10) and (ii) a PDD within Article 5(2) (including Article 5(2)(a)-(c)). The unexpressed reality of the ER is that anything which falls within Article 3(10) is presumptively a PDD; and eludes PDD status only if Article 5(2) is satisfied.

669. The majority Defendants' submission is in unacceptable tension with the wording of Articles 3(10) and 5(2) themselves. The definition of a defeat device in Article 3(10) does not include any justification. The first sentence in Article 5(2) prohibits "*the use of defeat devices that reduce the effectiveness of the emission control system*". So, the prohibition bites where there is a relevant modulation that is designed to operate differently in and out of test/reduces effectiveness of the ECS; there is then a PDD. One or more of the Article 5(2)(a)-(c) "*exceptions*" (described as such in *CLCV* at [105]) may then be relied upon to disapply the general Article 5(2) prohibition (in effect turning the PDD back into a DD), and must be interpreted strictly (*CLCV* at [112]), but that is a second, separate step.

670. That approach is consistent with *CLCV* at [88] which suggests that, in relation to the Article 4(2) provision, the burden is on the manufacturer. As the CJEU stated: "*Article 4… requires the manufacturer to demonstrate that the technical measures taken ensure that the tailpipe emissions in particular are effectively limited…*". It also aligns with:

    i) The opinion of AG Rantos in *GSMB Invest* (AGO) at [127];

ii) The fact that areas of EU law where EU legislation does not expressly provide for which party bears the burden of proof, the CJEU has also held that the party seeking to rely on an exception to a scheme of EU rights/prohibitions bears the burden of justifying that exception's application;

iii) This itself derives from the common and civil law maxim that the alleging party bears the burden of proof (*actori incumbit probatio*) ("the Alleging Party Principle"), which precludes a party from having the burden of proving purely negative facts: see judgment of 10 May 1990 *Sens v Commission* T-117/89 EU:T:1990:30, at [20]; or *Opinion of AG Tesauro* of 5 June 1997 *Blackspur DIY v Council of EU and Commission* C-362/95 EU:C:1997:281, at [26].

671. I understand and sympathise with the view that if (contrary to my finding) the Claimants' approach to Article 3(10) were to be preferred, the width of the obligation and the overlap of its contents with the contents of Article 5(2) would make it very tempting to reach the conclusion that the two parts there do operate as two parts of the definition of a PDD so as to shift the burden to the Claimants.

672. That, it has seemed in considering the submissions made, very much underpins the arguments advanced by the Defendants. However even so, I would conclude that the structure of the wording (prohibition defined followed by separate disapplication), the nature of the provision at Article 5(2) (exculpatory) and the nature of the exercise (detailed justification by reference to technical materials) all point towards the burden being on the Defendants at this stage. For the latter point I have firmly in mind the authorities on effectiveness and asymmetry of information. One example is found in *Oberbank AG and others v Deutscher Sparkassen- und Giroverband eV* C 217/13 and C 218/13 EU:C:2014:2012, where the CJEU relied on the fact that the proprietor of the trademark at issue was best placed to adduce evidence in support of his claim. It might be said (as Renault does) that the decision turned on the specific wording and objective of the directive in question. However, the approach appears to be more widely applicable and to be well founded in logic.

673. There is also further comfort to be drawn from the following (while the Defendants are right that they are none of them sufficiently on point to be assigned any substantial weight):

i) The (later) AES/BES provisions which require manufacturers to prove to the competent TAA that any AES is justified, and supported by appropriate safety studies or testing;

ii) The approach of the German and Austrian Courts. In the *BGH* decision (26.6.2023) VIa ZR 335/21, the court held at [54] that the burden of proof for the permissibility of a defeat device was generally borne by defendants following from the "*rule-exception relationship of Article 5(2) of Regulation (EC) No. 715/2007, because the use of a defeat device is generally prohibited under Article 5(2) sentence 1 of Regulation (EC) No. 715/2007 and is only permitted as an exception under the specific conditions of Article 5(2) sentence 2 of Regulation (EC) No. 715/2007.*" ([54]);

iii) The decision of the Austrian Supreme Court (OGH) (27.6.23) 1 Ob 149/22a, where the court concluded that, "*a generally prohibited defeat device (a thermal window)*

is installed in the transferee's vehicle, the transferor bears the burden of proof that such a device falls under the exemption from the prohibition pursuant to Article 5(2) sentence 2(a) of Regulation 715/2007/EC" ([46]; [42]-[43]).

674. The Defendants' reliance on domestic authorities does not assist. They pointed first to *Abrath v North Eastern Railway Co* (1883) 11 QBD 440 for the following passage "*If the assertion of a negative is an essential part of the plaintiff's case, the proof of the assertion still rests upon the plaintiff. ... Wherever a person asserts affirmatively as part of his case that a certain state of fact is present or is absent, or that a particular thing is insufficient for a particular purpose, that is an averment which he is bound to prove positively*." Reference was also made to the more recent case of *Emmanuel v Avison* [2020] EWHC 1696 (Ch): "*The legal rule is ... that where a given allegation, whether affirmative or negative, forms an essential part of party's case, the proof of such allegations rest on them*" per Birss J at [54].

675. That is not an entirely comfortable result if the Claimants were right about the approach to Article 3(10), and it forms one of the stages in iterating the Article 3(10) interpretation exercise accordingly, as already noted.

676. Having said that, the Mercedes argument offered a further potential way of balancing the burden, namely to contend that (i) it is indisputably the Claimants' burden to prove that the impugned functionalities are DDs in the first place and therefore the Claimants' burden to prove that each functionality they impugn is not necessary for stable combustion; and (ii) where a modulation is necessary to maintain stable combustion, there is no DD and that is the end of the matter, without Article 5(2) ever being engaged. Again this appeared to be an argument which really was aimed at the widest iteration of the Claimants' argument – in particular the version in which (contrary to the above) the Claimants succeeded in establishing their Normal Driving Conditions ranges. Stable combustion is a concept which became on the evidence a running theme in relation to the extremes of temperature and altitude. Given the findings I have made NDC effectively deals with areas where stable combustion are in focus, and therefore this point falls away. Were different conclusions to be reached on NDC, and if Article 5(2)(a) had to be read cumulatively, it might well be that this argument could gain traction.

677. Finally in any event there is a further wrinkle to the burden of proof argument. That is the question of burden of proof on alternative technology. The burden of proving an exception is on the Defendants. However I consider that if the Defendants establish a *prima facie* case that a device is needed to prevent damage (as that term is to be properly construed) and the Claimants wish to challenge that by reference to an alleged alternative technology which means that the particular device is not needed, the burden of proving that technology and its availability shifts to the Claimant. The structure is not dissimilar to the position encountered in charterparty cases where damage to goods falls to be proved by the claimant, perils of the sea by the defendant and an allegation of negligence disentitling reliance on perils of the sea must be proved by the claimant: *The Glendarroch* [1894] P 226; *The Popi M* [1985] 1 WLR 948.

PDD Legal Issue 6: "Engine"

678. Article 5(2)(a) applies only where: "*the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle*".

679. The Claimants' case in essence is that the engine is solely the engine i.e. the core combustion engine, which is narrowly defined and treated as separate from the aftertreatment systems. The Defendants submit that the engine extends to associated systems, in particular emissions-related and air-handling components (EGR, LNT, DPF, DOC, turbocharger, etc).

680. This issue therefore focuses on whether risks to those components can justify calibration strategies that reduce ECS effectiveness.

681. The Claimants' case is that the term "engine" is a general one and can be used for many purposes. It plainly includes the combustion chamber and what happens in it (cylinders, pistons, crankshafts, valves). That is the core of the machine that converts energy into motion; also the literal definition of "engine".

682. They suggest that the balance of materials favours their approach noting that:

    i) While various EU regulations use the term "internal combustion engine" without defining it "because its meaning is inherently clear" the term has subsequently been defined in 2015 at the World Forum for Harmonisation of Vehicle Regulations to mean *"a propulsion energy converter designed to transform chemical energy (input) into mechanical energy (output) with an internal combustion process";*

    ii) "Engine" plainly does not include the things that happen after gases are ejected from the combustion chamber, and go on to drive the turbine (with the engine driving the axle, wheels etc) and thence into the aftertreatment system – pointing to terminology in the CATD which aligns with this: "engine emissions" (Appendix 3 §13); the DPF is said to remove PM from "the exhaust gas of a diesel engine" (Appendix 3 §16d); backpressure from the DPF can impact "engine behaviour" (Appendix 3 §49). Hence also the "engine temperature" is distinct from the exhaust and SCR temperatures (Appendix 3 §40h).

683. At the heart of the dispute is a faultline in the CJEU authorities. The Defendants point to *CLCV* which acknowledges the EGR at paragraph 83 is an "in-engine system".

684. The Claimants rely instead on *GSMB Invest*, where this provision was considered in relation to the EGR valve, the EGR cooler and the DPF; and in *IR* in relation to the EGR valve only, all of which manufacturers said would become clogged/stuck etc (with the risk of loss of acceleration etc) without the DDs. In both cases the CJEU held that these components were not part of the engine, and therefore a need to protect them would not offer any basis on which to justify a RIE of the ECS (*GSMB Invest* at [51]-[52], *IR* at [64]). It did so on the basis that the legislation (when considering what falls within an existing TA) "*makes an explicit distinction*" between "engine" and the "emissions control system" in Annex I point 3.3.1 IR which distinguishes "*vehicle, engine or pollution control system parameters*" and then confines "engine" to the cylinders, valves, fuel system, cooling system and combustion process, and also Article 10(1) IR. This approach reflects the analysis of the Advocate-General. Thus the CJEU in *GSMB Invest* at [59] when considering Article 5(2)(a) contrasted damage to components of the EGR such as the valve, and damage to "the engine itself" (also at [60], and [62]).

685. The Defendants submit that this is another area where *GSMB Invest* should not be followed because:

i) The CJEU relied solely on Annex 1 paragraph 3.3.1 Implementing Regulation above, and did not make reference to the definition of the "Internal Combustion Engine" in the Framework Directive and Implementing Regulation;

ii) The list of components under the sub-heading "Engine" in paragraph 3.3.1.2 of Annex 1 to the Implementing Regulation is not intended to be exclusive.

686. I accept the Defendants' submissions. *CLCV* is binding and it is relatively clear that it saw EGR as part of the engine. That approach is entirely consistent with the regulatory framework: the definition of "Internal Combustion Engine" in the Framework Directive in Annexes 1 and III (see point 3.2.1 of Annex 1). These provisions set out the form of the information required to be submitted in an application for TA and include:

i) (3.2.8) "Intake System", including (3.2.8.1) "Pressure charger";

ii) point 3.2.12.1 "Measures taken against air pollution";

iii) "Catalytic converter" (point 3.2.12.2.1.1);

iv) "Exhaust gas recirculation" (point 3.2.12.2.4.1);

v) "Particulate trap" (point 3.2.12.2.6.1); and

vi) Additional anti-pollution devices (if any, and if not covered any another heading)" (point 3.2.12.2.1). (Annex 1 Appendix 3 to the Implementing Regulation is in the same terms).

687. The same is repeated, with the same numbering, in Commission Regulation 692/2008, Annex I Appendix 3, which sets out the requirements for an information document in an application for emissions TA. Further, Article 2(1) IR defines "*vehicle type with regard to emissions and vehicle repair and maintenance information*" by reference to the engine and vehicle characteristics as set out in Appendix 3 of Annex I.

688. As Ford notes, given that the immediate context to the prohibition of a DD in Article 5(2) is the need to demonstrate compliance with the Emissions Limits on the NEDC (in Article 4(1)) as part of the type-approval process and the inclusion of a DD would be a bar to type-approval, it would be surprising if a different definition of "engine" applied when submitting information for the purposes of type-approval and when assessing if an element of design was a DD.

689. The approach of *CLCV* is also in line with the expert evidence. Aside from the CATD, Mr Day's evidence was that as a matter of technical understanding the EGR system is integrated into, and part of, the diesel engine, and that the recirculation of exhaust gas via EGR is part of the process of combustion. Mr Smithers explained orally that in his view, "*the engine is everything. It's the cooling system, it's the engine, it's the aftertreatment, it's the entire power train"* – i.e. *"the whole of it from the intake point to the tailpipe*".

690. As for *GSMB Invest* the CJEU came to the conclusion it did so solely on the basis that point 3.3 of Annex I IR distinguishes between the engine and the pollution control system parameters. That is not a sustainable basis for the CJEU's conclusion, because, as noted above, other parts of the same Annex within the same Regulation expressly recognise

and state that the EGR system is part of the engine, as (most importantly) does the FD. Further the list of components under the sub-heading "Engine" in point 3.3.1.2 of Annex 1 to the Implementing Regulation is plainly not intended to be exclusive.

691. Further support for the conclusion that EGR is part of the engine comes from *Crossley 1* [155]. Contrary to the Claimants' submissions, that paragraph aligns with the Defendants' case in that, Waksman J rejects the "Locational Argument", which was an argument that EGR could not be part of the ECS because the EGR process occurs in and about the combustion chamber – in other words, that EGR could not be part of the ECS because it was part of the engine. Waksman J rejected that argument because it "*proceeds upon an artificial distinction which serves no purpose and has no legislative basis*". The "distinction" in question can only be between the ECS and the engine. Waksman J was, with respect, quite correct to say that this distinction was "artificial" for the purposes of Article 3(10) ER. The same must apply to Article 5(2)(a). Thus the EGR can be (and is) part of the engine as well as part of the ECS.

692. The other matters which the Claimants rely upon to shore up their case on this point (disclosure documents, regulations on heavy duty vehicles and "air-handling") do not add anything to the argument. Accordingly, while careful reflection has been necessary before departing from the decision in *GSMB Invest* (and hence *IR*) on this point, I am entirely persuaded that the line taken in *CLCV* was correct and that in this respect the court in *GSMB Invest* went astray. I note that it plainly did not have the detailed argument and technical evidence available to it of which I have had the benefit.

PDD Legal Issue 7: "Damage"

693. This point is a key construction issue, but simply stated. Article 5(2)(a) says this:

> "the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle"

694. The first thing to note is that the phrase "damage or accident" in the first limb has as its focus (and only focus) the engine. In *CLCV* the court applied a strict interpretation to this part of Article 5(2)(a) as an exception to the PDD prohibition. In response to VW raising the same risks of broad EGR use as are raised by the Defendants in the present case (namely "*clogging of air intake ducts, valves and the combustion chamber*", reducing "*engine longevity and reliability*" at [40]) the CJEU held:

> "108. In its usual meaning in everyday language, the term "accident" refers, as the Advocate-General observes in point 135 of her Opinion, to an unforeseen and sudden occurrence which cases damage or hazards, such as injuries or death. The term 'damage' refers, for its part, to damage generally resulting from a violent or sudden cause of action.
>
> 109. Consequently, a defeat device which reduces the effectiveness of the emission control system is justified where… it allows the engine to be protected against sudden and exceptional damage.
>
> 110. In that regard, it should be noted that the clogging up or the ageing of the engine cannot, in any event, be regarded as an 'accident' or 'damage', within the meaning of that provision, since… those events are, in principle, foreseeable and inherent to the normal operation of the vehicle....

> 113. The general prohibition against DDs in Article 5(2) would be "devoid of substance and deprived of any effectiveness if car manufacturers were permitted to equip motor vehicles with such defeat devices with the sole aim of protecting the engine against clogging up and ageing."

695. Accordingly, the CJEU concluded that only "*immediate risks of damage which create a specific hazard when the vehicle is driven are such as to justify the use of a defeat device*" (*CLCV* at [114], *GSMB Invest* at [56], [62] and [70], *IR* at [68] and [74], *DS* at [67] and [73], *DUH* at [89], and *QB* at [64].

696. There have been limited attempts by the Defendants to evade this approach. It is plainly the right approach to take if (as I have found) Article 3(10) is directed at CRDDs (as Ford acknowledges). To the extent that the point was contested I will simply record here that I concur with that line of reasoning.

697. The bigger issues are:

    i) The role of the "and for safe operation" element: whether it is a cumulative condition or in effect a separate exception;

    ii) Whether the damage to the engine needs to be "sudden and irreparable".

Safe: cumulative or not?

698. On the question of cumulative or non-cumulative on safe operation, the Claimants' case – which has considerable immediate attractions – may be summed up thus:

    i) That is what it says on any normal reading;

    ii) That is what CJEU authority says it means (*GSMB Invest* and *DUH*).

699. Notwithstanding this (and the Claimants' characterisation of the contrary argument as "hopeless") I have been persuaded that the correct answer to this point is that the conditions should be read disjunctively. That a disjunctive reading of what on its face appears cumulative is in some cases permissible as a matter of law is well established as the VW/Porsche skeleton helpfully summarised: Bennion, Bailey and Norbury on Statutory Interpretation (9th ed) at §17.11, the word "and" "*may be used disjunctively as well as subjunctively*" *John G Stein & Co Ltd v O'Hanlon* [1965] AC 890 (HL) *R v Oakes* [1959] 2 *QB* 350 (CA) *Blackpool Council Licensing Authority v Howitt* [2009] PTSR 1458 (HC) *DH v SSHD* [2020] UKUT 223 (IAC).

700. That the disjunctive approach makes sense was a point powerfully made by Mercedes, who highlighted the absurdity which results otherwise. In the first place it means that a DD that is not required for protection of the engine cannot be justified even if that DD is required for safe operation of the vehicle. In other words, on the Claimants' case, there may be a really serious risk to the safe operation of the vehicle – but if it does not impact upon the engine it is irrelevant. That is absurd on any view even if (as I have found) a slightly broader view than that advocated by the Claimants should be taken.

701. The Claimants say that the protection is unnecessary because manufacturers are legally obliged to ensure that their vehicles operate safely. But their case here involves saying that manufacturers are prohibited under the ER from modulating the ECS even if such

modulation is necessary for safe operation – unless it is also necessary for (narrowly defined) engine protection.

702. This approach renders "*the safe operation of the vehicle*" essentially otiose, and even more so if the term "damage" must be interpreted as arising from a "violent or sudden cause of action" below. It is next to impossible to conceive of "*damage or accident to the engine*" that would not also impact on "*safe operation of the vehicle*".

703. The major issue with the Defendants' approach is, again, *GSMB Invest* where the CJEU simply states, without analysis, that "*in view of the use of the conjunction 'and' in that provision, it must be interpreted as meaning that the conditions laid down therein are cumulative*". While again considering very carefully whether this clear ruling should be followed by this court or not, I conclude that to do so would be wrong.

704. The dictum in *GSMB Invest* is arrived at almost in passing and without analysis. It may well be that the court was not made aware of the possibilities which flowed from this dictum; as I have noted, the resources available to it were significantly less than those I have been afforded. Nor does it appear that the Court was made aware that the "safe operation" provision had been added as an additional, alternative justification separately by the Council – the original provision had only covered engine protection. Certainly paragraphs [59-60] do not suggest that any of this was put to the court.

705. The impression that this was not a fully considered ruling is reinforced by the facts that it is arrived at without referring to "*the spirit, general scheme and the context of the provision or the practicalities of its operation*" nor to the EU law principle that measures should be given their full, useful effect and that courts should prefer an interpretation (consistent with the objective of the measure) that does not render the provision redundant or ineffectual.

706. The Claimants' argument that a disjunctive reading would dangerously expand Article 5(2)(a) by, for example, permitting manufacturers to invoke "*safe operation*" to justify measures addressing ammonia slip is a "*bootstraps*" argument. What justifies an exception for safe operation, and the gravity of the risk involved in (say) ammonia slip are other questions. But sticking with this point: the better reading of this provision is that it provides an exception both for engine damage and for safety.

Sudden/exceptional?

707. There is then the question of whether engine damage needs to be "sudden" or "exceptional". The reason why this is an issue is because the Defendants would wish to say that the risks which can follow from clogging of the engine (uncontrolled acceleration, loss of power and fire) are the kinds of damage contemplated. Again the issue stems from the judgment in *GSMB Invest*.

708. The CJEU in *CLCV* held that the term "damage" in Article 5(2)(a) meant "*damage generally resulting from a violent or sudden cause of action*". The CJEU relied on the AG's Opinion on this point and there is no analysis of the term in the judgment. Because the questions were referred to the CJEU by the Tribunal de Grande Instance de Paris (Regional Court, Paris) the AG centred her analysis on the term "*dégât*" in the ER's French version, which term is defined in Le Petit Robert dictionary as "*generally resulting from a violent or sudden cause*". She noted that the English term is defined as

"*physical harm that impairs the value, usefulness, or normal function of something*" but stated that this did not, in her opinion, "gainsay" the meaning of the French term. The CJEU judgment does not consider the different language versions.

709. The German Government argued in *GSMB Invest* that the condition that damage be "sudden" should not be imputed into the definition of damage as the definitions of the relevant English and German terms ("damage" and "*Beschädigung*") do not refer only to sudden and unforeseeable events. In *GSMB Invest*, the AG noted that the definition of the French term "*dégât*" (from the dictionary of the Académie française, rather than Le Petit Robert) did not require damage to be from a sudden event. The CJEU noted the distinction between the French and English/German definitions and stated that although the English and German definitions "*do not necessarily imply that a removal is due to a sudden event, they do not invalidate the Court's interpretation of the word 'damage'*". As such, the CJEU's interpretation of the French term "*dégât*" in *CLCV* was carried forward.

710. Where this comes out is that the Court in *GSMB Invest* concluded in absolutely clear terms that a defeat device

> "can be justified under [Article 5(2)(a)] only where it is established that that device strictly meets the need to avoid immediate risks of damage or accident to the engine, caused by a malfunction of a component of the exhaust gas recirculation system, of such a serious nature as to give rise to a specific hazard when a vehicle fitted with that device is driven".

711. That authority has been followed in a veritable welter of later cases: *DUH, QB, CM*.

712. The Defendants say that whilst this court is bound by *CLCV*, that case can be confined to its facts; it does not require the Court to adopt the Claimants' restrictive interpretation. They contend that I should conclude that "damage" is not confined to "*sudden and exceptional*" damage.

713. The Defendants deploy a raft of arguments. In summary:

i) The CJEU in *CLCV* stated that "damage" refers to damage "*generally resulting from a violent or sudden cause of action*";

ii) The CJEU did not refer in *CLCV* to the different language versions of the term; it simply adopted the French definition set out by the AG (by reference to a single French dictionary) without further analysis;

iii) A consideration of all the other language versions (albeit then translated into English) suggests a wider approach and that is consistent with In *Re Olympus UK Ltd* [2014] Bus. L.R. 816 at [61] per Hildyard J saying that to avoid inconsistent application the most liberal approach in the language versions should be preferred;

iv) *CLCV* considered clogging in isolation – divorced from the other risks which accompany it;

v) There is no qualifier to damage as is often encountered in regulations;

vi) The suddenness requirement duplicates accident;

vii) English law requires an English language interpretation under s. 3(4) EUWA.

714. All of these points are very well made and deserve serious consideration. However I do not regard it as possible to confine *CLCV* to its facts and that being the case, this court must follow it.

715. That is a conclusion which may well be palatable in the context of the approach to Article 3(10) which I have taken; because on that basis it is obviously undesirable for the exceptions to operate more than truly exceptionally, and I have already concluded that safe operation is to be read disjunctively.

716. However I do agree with Ford's submission that *CLCV's* reasoning is far less plausible when applied to the kind of minor or *de minimis* modulations that, on Claimants' case, are caught by Article 3(10). It appears hard to see any regulatory policy reason why such minor modulations could not be justified by reference to damage or safety risks falling short of the unforeseen or catastrophic.

PDD Legal Issue 8: "Accident"

717. The arguments on this limb largely derive from where one might or might not land on the other issues.

718. The Claimants submit that "accident" (against which the engine is protected) refers to an unforeseen and sudden occurrence which causes direct immediate damage or hazards such as injuries or death: *CLCV* at [108]. They submit that it must be read conjunctively with "safe operation of the vehicle". Elsewhere and inconsistently they suggest that the focus of accident needs to be the engine ("*a simple breakdown … is not an accident against which the engine needs protecting*").

719. For the Defendants the word should be given its ordinary English meaning, such that it covers breakdown of the vehicle or its components and any type of unsafe situation in, on or around the vehicle. For Mercedes, for example ammonia slip can be an accident.

720. It is fair to say that the question of accident has not to date received much in the way of air time. Nor, as matters have developed in this case, do I regard it as a part of the ER which comes into sharp focus. The conclusion to which I would come (to the extent it is needed is as follows):

i) The ordinary meaning of the word should be observed. I would not substantially part company with AG Sharpston at [135] in *CLCV* though I would probably omit "injury or death";

ii) The context demands that the accident leading to damage or danger here must relate to the engine. That would in my view exclude ammonia slip. That is a conclusion which will be more tolerable to the Defendants in the light of the earlier conclusion on disjunctive reading of safe operation.

PDD Legal Issue 9: "Safe operation"

721. Legal Issue 9 asks: What is the meaning of "*for safe operation of the vehicle*" in the context of Article 5(2)(a)? This issue brings into focus the difficult issue of what safety entails in this context, in particular given arguments by the Defendants that safety

encompasses safety of others (including harm caused by ammonia slip) and for some Defendants harm to bystanders and car specific issues such as fire and loss of power.

722. The Claimants' case is that this issue is decided, that the law is clear that there is no broad, free-standing safety exception, let alone one that is probable or contingent. What matters is not the possibility of long-term deterioration, but whether a direct risk would give rise to a concrete or specific hazard while the vehicle is driven. The emphasis is on a "specific" or "concrete" danger when driving. If this "specific" or "concrete" danger can be sufficiently managed by e.g. the OBD system in relation to DPF regenerations or the EGR, then it does not qualify as a risk to the safe operation of the vehicle. The Claimants say that this follows from both binding, and non-binding CJEU decisions and national decisions following them.

723. That legal context is this.

    i) *CLCV* (binding) at [114] – though subject to arguments as to whether this part of the wording is in focus;

    ii) *GSMB* Invest at [61]-[62];

    iii) *IR* at [72]-[74];

    iv) *DS* at [72] and [81]-[82];

    v) *DUH* at [95];

    vi) *QB* at [62] and [64];

    vii) *GSMB Invest (AGO)* [108].

724. The Claimants add that it is also settled law that it is not a general safety margin or a hedge against longevity issues. It does not cover long term wear and degradation and regular and appropriate maintenance of the vehicle has a role to play in the assessment of whether that could not prevent such an effect: *GSMB Invest (AGO)* at [125]-[126] (as to EGR valves and thermal window); *Opinion of AG Rantos* of 2 June 2022 *QB v Mercedes-Benz Group AG* EU:C:2022:420 at [37]. This is aligned with the CJEU's view that the expense of technical devices or more costly vehicle maintenance are not valid arguments under Article 5(2)(a): *DUH* at [93].

725. The Claimants also contend that the reading of the term has to align with the approach to the word "accident" and as such it must involve an exceptional safety critical scenario, not the kind of engineering trade-offs inherent in diesel calibration. On the Claimants' view most of the risks relied on by manufacturers are really issues of durability or optimisation which fall well outside the scope of Article 5(2)(a).

726. For the Defendants this narrow view is at fault because it excludes a significant number of circumstances which plainly do have safety implications, such as combustion instability or stalling, sudden loss of torque or power, abnormal exhaust temperatures affecting nearby components and unpredictable drivability responses that could endanger occupants, other road users and even bystanders and would undermine the preventive purpose of Article 5(2)(a). They dispute the blanket approach to long term wear, contending that there comes a point where physical or chemical limits become real risks

in ordinary driving and that thus things like soot loading can become safe operation factors.

727. The starting point must be the extent to which the ground is dictated by *CLCV*. As to this, while the Claimants say that this issue is decided, I am not persuaded that that is so. The Claimants' formulation is derived from [146] of the AG's opinion in *CLCV* considering an argument from the Italian Government (summarised at [138]) that "damage" should be extended to include wear and tear, which at [140] rejects the argument explicitly by reference to "damage" and concludes that "*only immediate risks of damage which create a specific hazard when the vehicle is driven are such as to justify the use of a defeat device*". The Defendants are right that *CLCV* was not considering this part of the Article. There is nothing in the judgment itself at [110-114] which suggests that the Court had "panned out" or brought "safe operation" explicitly into focus. At [110] the Court talks only of "accident" and "damage". The term "safe operation" appears only in passages which recite the Article or the question referred. The overwhelming impression is that there was no separate consideration of "safe operation" and that the decision relates to "damage".

728. Against this background the finding in the (non-binding) decision in *GSMB Invest* that the phrase means *"that a vehicle operates without the malfunction of components of such a serious nature as to give rise to a specific hazard"* does not build on a *CLCV* foundation. Nor does it show a basis which would make that conclusion compelling. As was argued in oral closing this approach would mean that a manufacturer could not justify a defeat device necessary to avoid endangering vehicles or persons, because the vehicle would somehow nonetheless be regarded as operating safely and a risk of (say) ammonia slip (however serious) would never be able to come within this limb. That is a proposition which seems bizarre, given the environmental and health concerns which the Claimants are otherwise so keen to espouse as the primary (or on their case sole) purpose of the ER.

729. On this basis the authorities do not provide any constraint and I am free to consider this simply as a part of the overall construction exercise.

730. However, considerable caution must be exercised here. The cases put by the Defendants on justification are so diffuse as to illustrate the concerns expressed by the Claimants and are reflected in the instinctive reaction of the courts which have touched on this subject. This is perhaps more so against the approach which is here taken to Article 3(10). On that basis we enter this question against a background where a manufacturer has created a device which is designed to perform better in test than out to enable it to ensure that the vehicle passes the test. That is hardly the background where it would seem likely that the legislator intended wear and tear, non-specific and hard to quantify risks of a vehicle at some point misfiring or losing power to offer the manufacturer a means of escape.

731. The Defendants' case in argument sometimes teetered close to suggesting that any risk would justify the use of a DD. But if that were right, the ambit of the exception would be very wide indeed, such that there would be a real risk that Article 5(2)(a) would operate more than the prohibition. This cannot be what the regulatory scheme sought to achieve. The CJEU (admittedly in non-binding decisions) has made clear that this outcome would disproportionately infringe the aim of limiting NOx emissions and must be avoided; and it is also not compatible with the approach taken by the Commission to AES/BES justifications in the later iteration of the scheme.

732. The way to guard against this appears to be essentially the reasoning which one sees in the case law (non-binding as it may be) – a need for a focus on significance and immediacy and a good starting point will be the formulation in *CLCV*. The statement of the Administrative Court (VG) Schleswig-Holstein (20.2.2023) applying the CJEU caselaw at [382]-[384] also provides a valuable and thoughtful input:

> "…safe operation of vehicles is about avoiding potentially serious consequences for significant legal interests. In addition to the imminent loss of significant material assets…due to damage to the vehicle, in the worst case, the right to life and physical integrity of the occupants may also be compromised…In view of this, the requirements for proof of a concrete danger must not be set too high. While the state must protect and promote these rights, it is primarily the responsibility of the manufacturer who wishes to bring vehicles onto the market to ensure their safe operation. Contrary to the legal opinion expressed by the defendant at the oral hearing, this is not about the necessary measures it must take to ensure product safety, but rather the emissions requirements of a vehicle type approval."

733. I do accept Mercedes' submission (also conceded by the Claimants) that "safe operation" is concerned with the safety of the vehicle when driven, including other drivers and road users. I would also be minded to accept that it can encompass the safety of passers-by and bystanders. This is borne out by both recital 3 of the FD and the fair balance between "*improving road safety and environmental protection*" described in recital 39 of FR (which anticipates replacement parts essential for emissions controls).

734. However I do not accept that "safe operation" should be seen as encompassing more diffuse issues such as generalised product safety. It also seems plain that the justification is not directed to wear and tear.

735. The million dollar question here is really this: Does this exception cover the kinds of risks which the Defendants prayed in aid?

736. An example is the question of ammonia slip. Taking a step to ensure prevention of possible emission of toxic (but at this stage unregulated) gases like ammonia because they are "inherently unsafe" would not, in my judgment be justifiable under this head on the materials which have been in play thus far. Whether the risk of ammonia slip justifies specific steps taken would require more specific and focussed considerations than this trial has seen; in particular as to the levels of ammonia generated by slips and how they manifest, the risks to human health and the environment both from an individual slip (to individuals in and/or near the vehicle) and from regular events inherent in certain dosing strategies as well as any evidence base as to accepted safe levels for ammonia slip (if any).

737. Certainly it appears possible, verging on likely, that ammonia slip at a sufficient degree of frequency/severity would fall within this definition. I note that Mr Smithers himself assumes in his report that limiting ammonia slip is a reasonable engineering goal and that the Claimants accept that "*variable dosing to reduce ammonia slip is not a per se reduction in effectiveness and can be permissible*".

738. Similar issues arise at other points in the argument: how severe/real need a risk from HP EGR operation at high temperatures be to permit reliance on this exception? Frequently

below, the answers given can only be indicative, because the issues were not fully in focus; with no agreement as to burden of proof here or how the definition was to be interpreted, often evidence on this issue was generic, or focussed on a range and not the specific point in issue.

PDD Legal Issue 10: DDs operating for most of the year

739. Following a line of non-binding CJEU authority, the Claimants contend that Article 5(2)(a) ER cannot apply to a device that operates "for most of the year". In *GSMB Invest* the CJEU held that although not a separate formal requirement in the ER, a DD which "*operated during most of the year*" to protect the engine "*would clearly run counter to the objective pursued by the regulation… and would result in disproportionate infringement of the principle of limiting NOx emissions from vehicles*".

740. This is an area where I see no merit in the Claimants' arguments. The words are manifestly not there – in a provision which as one can see from the earlier portions of this judgment was carefully drafted and amended in the drafting. Article 5(2)(a), which simply states, without qualification, that the prohibition on PDDs "shall not apply" whenever the expressly stated conditions are met.

741. The suggestion that this is a common sense argument fails to impress. The Claimants' submission that it is their approach that accords with common sense involves, in effect, ignoring Article 5(2)(a) ER altogether. They suggest that without a blanket prohibition on devices operating for most of the year, DDs would "*in effect become the default in material parts of the EU*". But that is to assume quite a lot about the nature of the device covered. If there is a device that is required for protection of the engine and/or safe operation of the vehicle because of a risk which arises now and then throughout the year (such as extreme torque demands) or even (in some jurisdictions – e.g. a potential DD to do with altitude pressure at the borders of NDC) why should that not be permissible? Why, if a modulation/calibration is proved to be technically necessary to ensure the safe operation of the engine should it not be permissible throughout the year? It was instructive that Mr Smithers tended to accept that at some point reduced EGR rates to maintain combustion were necessary; but if this argument were correct, every reduction in EGR rates necessary for that purpose could then never be justified under Article 5(2)(a) ER because those modulations would (necessarily) operate throughout the year. And why should it be more permissible to protect them against risks that arise only once in a blue moon?

742. It must be borne in mind that this is not a free for all – any DD (whether operating for most of the year or not) must still satisfy the requirements of Article 5(2)(a) ER, and it is only if a device is justified by reference to engine protection and/or safe operation that it will be permissible.

743. This supposed additional limitation was conjured from next to nothing by the CJEU in *GSMB Invest*, *IR* and *DS*. The relevant parts of *GSMB Invest*, *IR* and *DS* are not fully reasoned. The CJEU in *GSMB Invest* rightly acknowledged that this was a "*further condition… for the application of the exception*" and that Article 5(2)(a) ER "does not formally impose" any such condition. This itself indicates that the decision amounts to judicial legislation, not interpretation. I see much force in the submission that it would be contrary to legal certainty to impose on manufacturers a requirement not present on the face of the ER. In any event, it renders it unequivocal that the "most of the year"

limitation did not form part of EU law as at IPCD and is not part of retained EU law now. Despite this, the Claimants do little more than point to those decisions (and a few judgments of German courts that were bound by them) and assert that the Court should follow them. However, and on analysis, the proposed "*most of the year"* restriction on Article 5(2)(a) ER is beset with problems, as described at Mercedes Opening §293.

744. The Claimants point to the 2023 Commission Guidance regarding AES provisions (to which reference has earlier been made). However these will have been informed by the post-IPCD jurisprudence, as well as by the development of technologies in the intervening period and so cannot dictate the correct interpretation of the earlier ER.

PDD Legal Issue 11: "Need" and other technical solutions

745. PDD Legal Issue 11 is as follows: How is the word "need" in Article 5(2)(a) to be interpreted? Should it be interpreted such that the "need" for a defeat device exists only where at the time of Type Approval no other technical solution makes it possible to avoid damage or accident and risk?

746. The Claimants again argue for a very restrictive reading. They say that the word "need" in Article 5(2)(a) of the ER means that a DD is justified only where, at the time of Type Approval, no other technical solution makes it possible to avoid the risks of damage or accident to the engine.

747. This is also based on the decision of the CJEU in *GSMB Invest*, where the CJEU stated at [69]:

> "the "need" for a defeat device, within the meaning of that provision, exists only where, at the time of the EC type-approval of that device or the vehicle equipped with it, no other technical solution makes it possible to avoid immediate risks of damage or accident to the engine, which give rise to a specific hazard when driving the vehicle."

748. The Court there also in terms rejected the argument that a device could be permitted under Article 5(2)(a) of that regulation solely because, for example, research costs are high, the technical device is expensive or vehicle maintenance is more frequent or more costly for the user on the basis that it would jeopardise the aim of the scheme.

749. The Defendants contend for a multi-factorial exercise to be determined on a case-by-case basis. It is said to be an exercise involving judgement, based on engineering knowledge and experience and must be judged as at the time and not with hindsight. The Defendants argue that the content of "need" will depend on the context and the particular risk the DD is designed to protect against and may be determined by reference to considerations such as emissions impact, cost, vehicle, engine and emissions control design, availability and transferability of alternative designs, manufacturing lead time and production cycles, and a justifiable low tolerance of any risk that might affect safety.

750. The starting point is that "*need*" is obviously a word freighted with a high requirement – and need on its face leads one to a construction where this question of alternatives – and possibly others – must be asked. On one level the course charted by *GSMB Invest* is attractive because the approach advocated by the Defendants is not one which is going to be easy to assess, or predictable.

751. But the Claimants' approach is one which reduces this "exception" to vanishing point. A device can be justified only if this specific device and no other can protect the engine from the specific suddenly incurred damage. Again this approach is simply unrealistic, as well as being in essence contrary to the text of the Regulation.

752. To start with the latter, because this is a question of construction: again we find ourselves back at the question of the purpose of the ER. Yes, the primary purpose is emissions control; but it is not the sole purpose and it is emissions control which does not kill the golden goose of the car manufacturing market. As noted earlier the ER is clear about its desire to ensure businesses can do business: Recital (7) to the Emissions Regulation expressly requires account to be taken of "*implications for markets and manufacturers' competitiveness*" and "*the direct and indirect costs imposed on business*".

753. That is then reflected in:

    i) Article 12 of the Emissions Regulation which allows Member States to incentivise manufacturers to adopt future emissions technology in advance of the date that future emissions limits come into force. Not only does this dovetail with the expressed concern for car manufacturing as a business, but also it is logically inconsistent with the Claimants' approach. Why incentivise if there is (by the back door) an obligation, in that there is no exception if that technology exists (however prohibitively expensive it would be)?

    ii) The travaux for the ER which note that a further reduction of NOx emissions would be unrealistic "*since it would entail the introduction of NOx after-treatment systems, which are still being tested for light-duty vehicles and represent a niche market*". Thus, the Euro 5 standard was intentionally set at a level which would not require NOx aftertreatment, even though that technology existed at the time.

754. And then there is practicality. The Claimants see "need" as an absolute; whereas that does not follow. It is usually a question of fact or degree (see for example issues about disclosure). It has been held by the Court of Appeal and the CJEU, in a different EU law context, that a measure is "justified" does not require absolute necessity: see *R v Henn* [1978] 1 W.L.R. 1031 at 1036, and the *AG Opinion* in Case 34/79 which was adopted by the CJEU. As Ford point out there are nearly always theoretical alternatives that could be adopted, if at enormous expense or other great disadvantage. To say that something is "needed" is to say that such theoretical alternatives as do exist are not reasonable for the person concerned to adopt, not that there are no alternatives at all.

755. It is easy to posit scenarios which fall foul of the common sense test on the Claimants' approach. Ford offer as one example, a solution that avoided the damage but required weekly garage visits. That would plainly be unreasonable – yet on the Claimants and the *GSMB Invest* CJEU's approach such considerations would be impermissible. And what if there is a perfectly good alternative technical solution, but it is diamond-encrusted and thus comes at vast expense – with the result that the cost of it and the knock-on effect on pricing, would price a budget vehicle completely out of its category? As the Recitals to the ER make clear there must be a balancing exercise to ensure new diesel vehicles are bought. It does not meet the primary environmental protection purpose if the cost of new diesel vehicles is so great, or the safety risks of such cars are so high, that consumers either buy new petrol cars or prefer polluting second-hand cars. That that is a real risk is acknowledged by the European Parliament's Committee of Transport and Tourism which

noted that in some Member States "*higher new car prices will slow the process of fleet renewal which also should be considered as a clean air factor*".

756. The Claimants' approach, to say the diamond encrusted solution must still be adopted (and to simply assume no purchaser backlash so as to claim the uplift as damages) is simply unrealistic.

757. Further, the logical result of the argument is that the Defendants were under an obligation to use the best available technology, which is certainly not what the ER says, or appears to have intended. Such an approach could of course very easily have been drafted and made the centre of the ER. It was not. Instead, the obligation was limited to passing a certain test in certain conditions and not having any defeat devices unless they were needed to prevent engine damage etc.

758. If "needs" does not mean "*only this solution exists/an obligation to use best available technology*", what does it mean?

759. What it does not mean is that need is watered down out of existence. It will be judged on individual fact patterns, but there will be certain common themes:

i) Need relates to the specific device and what it does;

ii) Need relates to the risk which that device meets. That includes not simply the existence of a risk but an assessment of the likelihood and seriousness of the risk. Here the risk is part defined by the wording as to engine damage and safety. Fairly obviously in unhampered terms one would say that an insignificant or minor engine damage can be tolerated to a greater degree of likelihood than a catastrophic risk to user safety. For the latter there may well be some impact of a precautionary approach (Nissan opening 195);

iii) Need is extremely unlikely to be justified solely because of any of the factors identified by the court in *GSMB Invest* (research costs etc.). More likely is a calculus of risk met by the device and the costs involved in another course. Safety cost and other factors may well be relevant to the need and be inputs into the assessment of whether there is a need or not; they will never or almost never dictate the outcome;

iv) Need is not to be established by reference to anything which does not intersect directly with the particular risk of engine damage/safety and the means of dealing with that risk;

v) There is no generalised margin of appreciation, and the decision is not akin to a judicial review test. Either the device is needed for the relevant prevention of damage/safety purpose – on the facts – or it is not;

vi) The absence of the kinds of documentation used for AES/BES justifications is not determinative, because such requirements drive the production of a paper trail. Nor do AES/BES documents show what devices are justifiable, because they relate to a later regulatory regime, and further developed technology. However AES/BES processes do provide useful illustrations of the kinds of issues which might be regarded as necessary.

Alternative technical solutions

760. On this basis the fairly extensive evidence and arguments on alternative technologies does not arise. These will be dealt with individually (but shortly) below. But there are some overarching points.

761. Firstly, the Claimants' arguments sometimes strayed quite a long way from the real ambit of this argument, and became (in harmony with the dream car fallacy) arguments that manufacturers were at all times under an obligation to use the "best available technology". This was an argument which was plainly entirely contrary to the letter and spirit of the ER, which navigated a line between improving emissions and laying waste to the car market. PCD pointed (in the context of the SCR allegations) to the EP Opinion on First Reading of ER, p.41, where the EU Parliament recognised that a further reduction of NOx emissions would be unrealistic "*since it would entail the introduction of NOx after-treatment systems, which are still being tested for light-duty vehicles and represent a niche market*". In oral closing the Claimants expressly- and rightly - disavowed the "best available technology" argument.

762. Secondly, the Claimants' case was scattergun and unfocused. If an alternative technology was to be relied on it must be one which actually addressed the need for the particular Article 5(2) exception relied upon. It was often very hard to see how the technologies linked to the Article 5(2) case, though the pressures of time and the width of the Defendants' own cases sometimes fed into this issue. However, the net result was that all such cases remained a country mile from a pleaded case as to how the alternative technology should have been calibrated, or what difference it would have made (in terms of NOx and as regards the pleaded DDs) had the alternative technology been utilised.

763. Thirdly, the case often veered into blue sky thinking. If an alternative technology was something the Defendants should have used, it would have to be mainstream and properly available; not a footnote in an academic paper.

764. SCR:

    i) One of the Claimants' main arguments here is that SCR was available and so to the extent that manufacturers did not use it from the start that was an alternative technology which stops the manufacturer relying on Article 5(2). As it is put at one point in the Claimants' closing (not necessarily 100% consistently with other parts of the closing): "*No DD in any CSV can be justified if it did not have a (PDD free) SCR, which could have mitigated any reduction in effectiveness the Ds seek to justify*";

    ii) This was a case for the Claimants to prove. There are issues here – for example this was not supported by their Ford expert Mr Carder and was not put to Professor Millo. And (given the arguments about PDDs in SCR systems) it would be necessary to consider the exact technology alleged, how it could have been implemented and how it would have worked. This could involve an exercise akin to redesigning the vehicle in evidence. Again, Mr Carder's evidence was particularly helpful:

        "I have included the alternative technologies just to discuss that you could perhaps have better ECS performance outside of the NEDC and

so, you know, I didn't think it was my job to design a new Ford vehicle. I mean, I wouldn't be capable of doing that. So ... I was simply offering options."

iii) SCR was not without its own issues as far as the Claimants are concerned – hence the reference to PDD free SCR systems;

iv) There are also issues about timing and cost. As will be apparent – and particularly bearing in mind design freeze dates - for Euro 5 SCR was emerging, predominantly used in larger vehicles where its technical challenges could be more easily met. It was not clear that it would emerge to be a dominant technology (*inter alia* because of issues such as the need for AdBlue dosing and concerns that drivers would not be prepared to get top ups sufficiently often and might vote with their feet) and particularly at the less expensive end of the market there were issues as to the cost effect of using a new and expensive technology. And, as the EP opinion cited above makes clear, SCR was at Euro 5 level an emerging and not embedded technology.

765. LP/HP systems which the Claimants say (via PCD's vehicles) was an available technology. In reality:

i) As with SCR, HP/LP was emergent and was being used by some manufacturers only. Professor Martinez-Botas acknowledged that low-pressure EGR was not being widely used in Euro 5 vehicles. None of the Euro 5 vehicles analysed by the Commission Royal or the DfT contained a low-pressure EGR;

ii) It too was not a silver bullet – as the HP/LP PDD allegations make very clear. For it too therefore it would be necessary for the Claimants to show how a PDD free HP/LP system would work in the relevant vehicles;

iii) As with SCR, the evidence suggests that (predictably for an emerging technology) challenges including packaging, challenges and cost and control implications (with implications also for development costs). Professor Millo and Mr Carder's evidence made this clear with Mr Carder acknowledging the potential downsides of additional development cost, calibration complexity and a higher price for the consumer.

766. LNT: The Claimants' approach here is somewhat Janus faced. All the LNT vehicles are said to have PDDs as part of the LNT's workings. For a number, SCR is posited as the better course. In oral opening, the Claimants position was that SCR made "*the use of technology, like LNT…very difficult to justify*". And yet in closing LNT is put forward as a relevant alternative technology: "*using a properly calibrated LNT…is a relevant alternative technology because it would mitigate any reduction in effectiveness caused by a PDD.*"

767. Ammonia slip catalysts: it was the Claimants' case that the risk of ammonia slip "*could have been eliminated or better mitigated by an ammonia slip catalyst (*"*ASC*"*)*", which was available before launch and was later "mass adopted". The Claimants also contended that larger catalysts and calibration/system design improvements could have dealt with the risks. The Defendants contended that neither the use of an ASC nor a larger SCR catalyst would have eliminated the risks requiring cautious calibrations; ASC does not in particular address the root cause of the slip which is linked to system dynamics and

loading and risks to systems stability. Mercedes in particular characterise ASC as a downstream fix or mitigation which does not remove the need for dosing control. The Defendants also highlight the limits of ASC whose effectiveness depends upon temperature conditions and whose conversion rates may be limited.

768. Ammonia Storage and Delivery System: this system was unpleaded and Professor Martinez-Botas had accepted that it was "*never used in production by a manufacturer of light duty vehicles*".

769. WCAC: these use, respectively, air and liquid coolant as cooling media. Mr Carder accepted that they could present packaging difficulties due to space and the need to be located close to the engine block, as well as the need to redesign to incorporate valves, pipes, pump and radiator. There was also a cost.

770. Piezo injectors: very late in the day the Claimants alleged that Mercedes should have used piezo injectors rather than magnet injectors as this would access a greater range of EGR. This was not pleaded and came far too late. It also appeared on the evidence to be another speculative point. Although the Claimants had disavowed any best available technology argument, the fact that they were still saying in oral reply that Mercedes' (even later) response that they had reliability issues was "*precisely the kind of issue that requires explanation and should have been evidenced.*" In fact demonstrated that the limits of the proper argument were not being observed.

Articles 5(2)(b) and (c)

Article 5(2)(b)

771. Article 5(2)(b) permits the use of a DD in circumstances where "*the device does not function beyond the requirements of engine starting*" and so the Court is required to consider the meaning of "engine starting". There is no CJEU guidance on this exception.

772. The issue is not a PDD Legal Issue and may not necessarily have a large practical application to the sample vehicles, but it is in issue; the point being what does "engine starting" mean? Further, the fact of that issue means that it may well have a practical application somewhere in the universe of emissions disputes, so an indication as to meaning is worth giving.

773. The Defendants' position is that engine starting extends considerably beyond the initial key turn/press button seconds and extends for some period as the engine warms up.

774. Mercedes asserts that this period ends when the "*systems in place to ensure that the engine can start and run stably and safely are no longer required*", while Renault contends that period ends when the engine reaches "running temperature" (seemingly the entire warm up period until the coolant, i.e. the engine, has reached its full operating temperature). Ford's pleadings indicate that they seek a definition that encompasses at least part of the engine warm up phase.

775. The Claimants identify three fundamental difficulties with this approach:

    i) It fails to engage with the mechanics of engine starting, which is a process that is readily distinguishable from how the engine operates once it has started (whether

from a cold or hot start), i.e. engine starting does not mean 'the first part of driving', it means the starting of the engine;

ii) The wide definition is not supported by those mechanical experts who considered the issue at trial; nor is it supported by the European Commission; and does not reflect the standard definition used across the industry. It is also contrary to Ford's internal training materials;

iii) It fails to account for the fact that the exceptions must be interpreted strictly and therefore narrowly.

776. On this issue the Claimants have the better of the argument. Mechanically, the engine starting process is readily distinguished from the combustion process of a diesel engine as it requires the use of a starter motor to turn the engine crankshaft to commence combustion. It requires high temperatures and high quantities of injected fuel. It ends once the fuel ignites, combustion is autonomous, the starter motor is no longer required and the engine has transitioned to stable idling without use of the starter motor, such that the starter motor can disengage. Activating (for example) the EGR during this short period would be counterproductive, as it would reduce the heat of the combustion chamber. It is uncontroversial that engine warm-up is a secondary operation, which commences once the starter motor has disengaged and varies depending upon ambient temperature. This description illustrates exactly why an exception would be regarded by drafters as called for, and at what it should be expected to be directed.

777. In practical terms too, the Defendants' argument is unconvincing: if they were right this exception would apply to a considerable portion of the NEDC test since much of the test is carried out during engine warm-up. Indeed, the engine may only be reaching a stable equilibration temperature (as measured by the temperature of the coolant) at the end or near the end of the test.

778. While the 2017 Guidance and Ford's internal documents are not materials upon which reliance should be placed, they provide a confirmatory cross check:

i) The 2017 Commission Guidance recognises that EGR modulation or deactivation "*during the first few seconds upon cold engine start*" is permitted, pursuant to Article 5(2)(b);

ii) The view that engine starting is limited to the initial ignition of the engine, was adopted by Ford in their training materials and appeared overall to be Professor Millo's view as well as that of Mr Day.

Article 5(2)(c)

779. This leaves Article 5(2)(c) which provides that the prohibition on DDs does not apply where "*the conditions are substantially included in the test procedures for verifying evaporative emissions and average tailpipe emissions*."

780. Again this is not a PDD Legal Issue (save as to the burden of proof issue, which relates to Article 5(2) generally). But:

i) All the Defendants argue that an Article 5(2)(c) exception applies in relation to one or more of the DDs in their CSVs;

ii) The Claimants contend that Article 5(2)(c) is incompatible with the CRDD approach.

781. It is fair to say that this is a condition which seems to shift in the eye of the beholder; what it means depends upon the approach taken to PDDs. This is an impression reinforced by the Claimants' own shift in relation to this. In opening, in partnership with the initial expression of their case, the argument was that conditions are not "substantially" included if they are merely transitory conditions occurring for short periods; second, that "conditions" refers to the conditions under which the device operates both in the Test and off-cycle, and that these conditions must match for the exception to apply. They illustrated the second point with a hypothetical scenario involving a fixed EGR rate of 30% based on torque, appearing to suggest that for the "test-inclusion" defence to apply, all the conditions producing the relevant EGR rate on the Test and off the Test must be identical. Orally (perhaps reflecting the start of the move towards the "template" argument) the case was put in terms that its effect was that "*for the first modulation that occurs, your first point of comparison is going to be how the vehicle relevantly operated on the test*".

782. Ultimately I have concluded:

i) If the Article 3(10) definition is (as I have concluded) confined to CRDDs, then it must be right that this exception must be construed narrowly.

a) The Claimants are right to say that in order for the defence to be available in relation to a given EGR correction, that correction must be active in the test; however it cannot follow that the functionality produces the exact same result in all real world driving conditions. As Mercedes rightly point out, that would effectively deprive Article 5(2)(c) of any content;

ii) In this sub-clause "substantially" means that most of the conditions in which the functionality operates must be present in the test, and the conditions must also apply in the test for a "sufficient duration", which means they will not be substantially included if they only arise momentarily – it remains possible that they could occur for a short period (for example if they relate to conditions which occur only for a short time).

783. Mercedes also makes a point by reference to the RDE test, contending that if vehicles would have passed the RDE test if it had applied to them, any functionality that was active (or "substantially" active) in the RDE tests on those vehicles is not a PDD. That is because if these vehicles had been type-approved under Euro 6d-TEMP, the RDE test would plainly fall within "*the test procedures for verifying evaporative emissions and average tailpipe emissions*" and thus within the scope of Article 5(2)(c) ER and it would be paradoxical if a functionality was held to be a PDD in a vehicle that was subject to a less stringent emissions standard (Euro 6b) when that same functionality would not have been a PDD under a more stringent emissions standard (Euro 6d-TEMP). While there is a surface attraction to this point, it cannot logically be fitted within the wording of the clause and hence the argument.

Contingent analysis

784. The conclusion on Article 3(10)'s construction is one which has a wide range of "knock on" impacts. Technically, it means that it is unnecessary to make findings on the majority of the alleged PDDs which have never been characterised as CRDDs.

785. However this judgment is designed to provide guidance for the entire range of cases, including the Non-ALGLO cases. It is also close to a certainty that determined attempts will be made to appeal this decision. It is therefore imperative nonetheless to analyse the remaining issues even if less fully than might otherwise have been the case; and draw conclusions on how the allegations work on the evidence, whether or not that Article 3(10) analysis is correct. That includes conclusions on each of the alleged PDDs.

786. Those exercises can only sensibly be done by positing a contingent/fallback analysis. It is not, however, feasible to reiterate all the issues for all the possibilities on the Article 3(10) and Article 5(2) analysis. A preferred contingent analysis must be adopted.

787. While there were a range of answers given by the other Defendants, as well as the answer(s) given by the Claimants, I have already made clear that I am completely unpersuaded by the Holistic Approach. In those circumstances it is appropriate to base the contingent analysis largely on the Claimants' overall approach.

788. Lest there be any doubt, this does not detract from the issues identified with the Claimants' approach (on which there is commentary above and will be further commentary as appropriate below). But ultimately in my judgment the wording of the regulation, as clarified by the admissible legal authority, essentially points to only two possible routes:

    i) One is the route advocated by the majority of Defendants: which is not only capable of being seen (as I have) as the most legally robust approach, but which also offers a harmonious picture across the entire range of issues;

    ii) The other is the Claimants' interpretation (or a variation on it): which offers the instinctive approach to construction and can be said to be in tune with environmental concerns if those are taken as an overriding objective – but which creates a world of complications and infelicities in operation.

789. As I have also noted above, the Claimants' case is not entirely consistent or harmonious, and there are slightly different versions of it which might be capable of being picked. Ultimately, I will proceed for the contingent analysis primarily on the basis of what is essentially the Claimants' "template" approach. The essential parts of that approach are:

    i) Any calibration substantially used in the NEDC test is freely available to the manufacturers for use outside the NEDC test and is not in general a DD;

    ii) A differential usage of a template calibration (i.e. a disapplication or limiting of that calibration outside the NEDC) may be a DD;

    iii) In general, a calibration used at a certain point in the NEDC should also be used at an equivalent point in the real world.

790. I should add that I appreciate that there are problems with picking this iteration of the Claimants' case. It might well be said that it effectively renders Article 5(2)(c) otiose. However, it appears to be the iteration closest to the heart of what the Claimants have said repeatedly, albeit with slightly contradictory commentary in places. Further as noted above, the primary analysis also skates close to eviscerating another part of Article 5 – and what is permissible in the primary analysis should be equally so in the contingent analysis.

791. The template analysis is being preferred because it does at least offer one way to offer an alternative to CRDD and pursue the broader approach to interpretation of the definition without falling into the "dream car" fallacy. Its use as a contingent approach should not be taken as any indication that it is considered anything other than a poor second. It carries with it practical issues which are very serious – such as requiring the designers and calibrators to design a complex and expensive piece of machinery effectively with one hand tied behind their back.

792. For the contingent analysis I will also proceed on the basis of the conclusions reached above as to NDC and as to the interpretation of Article 5(2).

793. Finally, the analysis will generally consider RIE and Article 5(2) on the evidence specifically, even if briefly. That enables a second fallback to be worked through.

794. The results of these three analyses appear in the Conclusions section of the judgment. There is also, and possibly more user friendly, a chart at the back of Part 2 summarising outcomes and explaining in very brief terms where any arguments which fail break down.

795. The approaches are thus:

    i) Primary: CRDD analysis;

    ii) Contingent A: Template and judgment findings on NDC;

    iii) Contingent B: Claimants' analysis with RIE and Article 5 findings.

ACTIONABILITY AND BREACH OF CONTRACT

796. This section addresses the link between any finding of a PDD and an ability to make a claim for it by any individual Claimant. The question is whether a PDD is a breach of the ER or any domestic legislation. There are two means of approach – breach of statutory duty and breach of contract via statutorily implied terms.

Breach of statutory duty

<u>The arguments</u>

797. The Claimants contend that the inclusion of PDDs in the relevant vehicles amounts to breaches of statutory duties imposed by EU and UK legislation governing vehicle emissions and type approval. Those breaches are said to give rise to private law causes of action in damages. The Defendants, however argue that even if PDDs were established, the statutory provisions relied upon either do not create actionable duties, or

do not impose the obligations alleged, or are enforceable only through public law and regulatory mechanisms rather than private claims for damages.

798. It is fair to say that despite the range of issues in this case, and the complexity of the technical evidence, this cluster of issues may justifiably be regarded as the most dense. They are also vital, because if the Defendants are right on this issue, even if PDDs are established, the Claimants' claim would fail.

799. The Claimants' primary case is that the statutory and EU-derived provisions relied on are intended to confer private law rights, so that their breach is actionable by individual purchasers by way of damages for breach of statutory duty. Starting by reference to the questions set out in *X v Bedfordshire County Council* [1995] 2 AC 633 at 731 they say that a private law cause of action can arise if, as a matter of construction (i) the statutory duty relied upon was imposed for the protection of a limited class; and (ii) Parliament intended to confer upon that class a private right of action for breach of that duty.

800. It is the Claimants' contention that the ER, read together with the FD and its successors, imposes legally binding and sufficiently precise obligations on manufacturers. They approach this either from a "Direct applicability analysis" or an "EU Parent analysis" or an "Implementing Choice Analysis".

801. In particular, the Claimants contend that:

    i) The CJEU decision in *QB* (and also that in *CM*) establishes that the relevant EU provisions generate individual rights, which domestic law must recognise and render effective, including by damages where appropriate;

    ii) Articles 4(2), 5(1) and 5(2) of the ER, which require emissions to be "effectively limited" in normal use and prohibit defeat devices unless narrowly justified;

    iii) Implementing and documentation regulations governing TA, conformity of production, and in service conformity;

    iv) Domestic implementing measures in the UK, including the Road Vehicles (Approval) Regulations 2009 and the Road Vehicles (Approval) Regulations 2020;

    v) Certain provisions of the Road Traffic Act 1988 and the Construction and Use Regulations as subsidiary bases for breach;

    vi) The Claimants argue that these provisions collectively impose duties owed not merely to regulators or the public at large, but to vehicle purchasers and users as a class.

802. In advancing these arguments the Claimants rely on something which they have termed the "*common regulatory framework*", or "CRF". In essence this is the collective term for every (EU) legislative instrument relating to TA and emissions control. This shorthand is criticised by the Defendants on the basis that it was used as a handwave by the Claimants where they could not find any specific instrument which supported their case.

803. The Defendants, in contrast say that:

    i) *QB* has not sold the pass;

ii) Even if it has, this court can decide the matter without regard to that decision;

iii) The regime is a public/regulatory enforcement framework, deliberately calibrated by the legislator, and not intended to give rise to private law claims for pure economic loss (save where expressly provided);

iv) The *ex ante* and *ex post* protection via type approval, market surveillance, regulatory enforcement action and existing civil causes of action offer a variety of protections and recourses;

v) There is no discernible intent by Parliament to create a cause of action to protect purchasers against pure economic loss caused by the presence of a PDD.

Analysis

804. The argument in this area, massive and somewhat diffuse in opening, moved helpfully over the course of the hearing, in terms of acceptance of certain principles and focus on strategically key points.

805. It is thus accepted by the Claimants that insofar as EU law actionability and domestic law actionability are distinct, they do not press a case that the domestic law provisions read alone and divorced from what they term "the CRF context" show an intention to create an actionable private law right. In other words, to the extent that nothing is created by the EU Law statutes, domestic law cannot fill that gap.

806. It is also now not disputed that:

i) When assessing an EU instrument, one needs to apply EU canons of interpretation;

ii) Different items of legislation can be interpreted in light of each other when those items are either derived from one another or are clearly otherwise related.

Direct effect

807. The first really controversial issue is whether the question of direct effect needs to be dealt with prior to any consideration of actionability. The Claimants submitted that:

> "The key point is that if the instrument is a regulation, the instrument is by definition directly applicable…That means that all aspects of the regulation take immediate effect in a domestic system without implementation…They are capable of enforcement against private persons if the relevant obligation has been breached…there is no necessity to look for or frame a claim in direct effect…Instead, what you do is simply the construction exercise [established in X]…applying EU law principles of construction, and if that test is passed, actionability follows".

808. As a statement of the law, this was less contentious than it may have appeared. Regulations are directly applicable (in the sense that they do not require implementation by the national legislature) and they are horizontally directly effective (in the sense that they can be relied upon in private law). The CJEU in Case C-253/00 *Muñoz* at [27] said this:

> "Pursuant to the second sub-paragraph of article 189 of the EC Treaty (now the second sub-paragraph of article 249 EC), regulations have general application and are directly applicable in all member states. Accordingly, owing to their very nature and their place in the system of sources of Community law, regulations operate to confer rights on individuals which the national courts have a duty to protect..."

809. There was a certain amount of debate as to whether the Claimants' approach featured a missing stage in the analysis, eliding applicability and effect. The Claimants however concede the requirements set out in Judgment of 5 February 1963 *NV Algemene Transport- en Expeditie Onderneming van Gend en Loos v Netherlands Inland Revenue Administration* 26/62 EU:C:1963:1. Thus it is not in issue that to have direct effect the regulation must meet the basic requirements of being clear, precise, unconditional, and not requiring additional implementing measures.

810. On this basis, in this case, given direct applicability it would seem that direct effect should follow, save to the extent that the ER can be criticised for want of certainty. As noted by Mercedes in closing, that is far from being an impossibility: The CJEU has at least twice held that an EU Regulation was not directly effective because it was not sufficiently clear and precise in the absence of implementing measures. These cases include Case C-403/98 *Azienda Agricola Monte Arcosu*, and Case C-509/11 *ÖBB-Personenverkehr AG*. In each case, the Regulation in question required national implementing measures and the CJEU held that litigants could not rely directly on the Regulations where the measures were inadequate.

811. Here of course there is an interesting interplay with the arguments made on whether the definition of a PDD ought to be limited only to CRDDs. MB submitted that the ER can only be certain for direct effect purposes if a PDD is so limited. Given the conclusion which I have reached on this, it would follow that this element of the dispute falls away (although Mercedes put down a marker as to actionability in damages).

812. Were I found to be wrong about the issue as to ambit of Article 3(10) (CRDD), it is appropriate, given the complications and the variety of answers which could be given, that the court considering the matter should re-iterate this actionability argument. I therefore do not attempt a "fallback conclusion" on this issue.

813. Here, of course, fits in the submission made by Mr Blakeley KC in closing, that no-one watching the trial *"can say with a straight face"* that the regulation is clear and precise and that (possibly as a consequence) the Claimants' evolving case was to the last contradictory and imprecise. However it seems inherently likely that if (contrary to my conclusion) the definition is wider than the one I have decided is correct (and pace my concerns as to the uncertainties of the alternative approaches which have in part informed the conclusion on that issue), any court which finds that this is the preferable construction (bearing in mind the requirement of certainty at that level) will necessarily conclude it must be one which is sufficiently certain for regulatory purposes. Having said that I note that in *AGIM*, the reason why the Directive was said to lack direct effect was because the relevant provision did not specify the criteria against which a review was to be carried out. It might well be argued that, if NDC and/or RIE are given the meanings the Claimants contend for, manufacturers would lack a clear or workable understanding of the criteria against which they must develop vehicles. That approach dovetails with Mr

Carder's observation that he did not envy the Court in having to draw a line as to emissions outside the NEDC cycle.

814. For present purposes however the obligation passes on the primary construction and should be tentatively assumed likely to pass on any contingent consideration and direct effect is or can be assumed to be established.

815. Further I find some attractions in the argument advanced by the Claimants in closing that in practical terms there is little difference between an EU level decision on direct effect and on actionability given the moving parts in each argument an affirmative decision on actionability will almost certainly presuppose an affirmative decision on direct effect.

Actionability if direct effect: Parent analysis and QB

816. The next main issue therefore is the proper approach to *QB*. The Claimants contend that it (and *CM*) establishes that the relevant EU provisions generate individual rights, which domestic law must recognise and render effective, including by damages where appropriate.

817. The Defendants' argument in briefest summary is that the CJEU's conclusion in *QB* was not that Article 5(2) ER, standing alone, confers rights on individuals. Rather, the CJEU held that Article 5(2) ER read with various articles of the FD conferred such rights and that since directive based rights and obligations are not carried forward post IPCD they do not exist in UK law, still less establish domestic actionability. They add that *QB's* reasoning rests on a new post-IPCD reading of the Framework Directive – specifically Articles 18(1), 26(1) and 46 – to create a right to financial compensation for the purchaser of a vehicle. Those rights were not recognised by the CJEU or any domestic court in a case decided before IPCD. They also say that *QB* is anomalous and deeply flawed and that the CJEU expressly left domestic rules on remedies to national law; *QB* does not compel recognition of a new tort.

818. It is true that there is an element of discomfort in an argument which starts (as Mr Blakeley KC pointed out) from a point where not one single item of domestic legislation is relied upon in an area where national procedural autonomy prevails. However the Defendants were not able to say that the structure of the argument is at fault or that the point is not open to the Claimants. It must therefore be addressed on its merits. And I conclude that the argument that it was not Article 5(2) "standing alone" which conferred a right on individuals, but instead Article 5(2) as read with provisions of the FD, means that the Defendants' argument that the right in question cannot exist in UK law because rights arising from a directive were not carried forward after Brexit is unsustainable.

819. The Claimants' summary of *C G Fry & Son Ltd v SSHCLG* [2025] UKSC 35 as it relates to the interplay between regulations and directives was not disputed directly. While *Fry* is not about actionability or the creation of private rights, and does not itself answer the important *X v Bedfordshire* questions, it has significance as a stepping stone on the question of the approach to construction.

820. In *Fry* the Supreme Court held that under ordinary domestic law principles of interpretation, an EU Directive (there, the Habitats Directive) was relevant to the purposive interpretation of domestic implementing regulations (here, the UK's Habitats Regulations) (at [44]-[51]) as part of the "*historical context*" of the Habitats Regulations

([47]). The Court considered that the purpose of the Habitats Regulations followed that of the Habitats Directive: it was *"to implement and follow the Habitats Directive in pursuing the same objective"* ([51]). Accordingly the domestic regulations were broadly construed so that they applied to what was called a *"multistage planning regime*".

821. It follows that (i) that domestic legislation which implements an EU directive must be construed in the context of the directive being implemented and (ii) a regulation can be examined in the broader legislative context of which it is part, including in relation to a pre-Brexit directive - whether or not the domestic cause of action accrued pre- or post-IPCD.

822. On this basis, as the Claimants submitted, if the EU parent scheme read as a whole is intended to protect individuals and requires actionability, then that must satisfy the *X v Bedfordshire* criteria.

823. As to this, there is nothing, per *Fry*, about Brexit which interferes with an English court's ability to infer the purpose of an EU regulation by looking at the broader EU level scheme – including a directive – of which it forms a part.

824. Nor is it correct to say, as Mercedes do, that the right itself is generated not by Article 5(2) but instead by the FD. That is a conclusion reached in the first paragraph of the operative part of *QB*:

> "[Provisions of the FD]…read in conjunction with Article 5(2) [of the ER]…must be interpreted as protecting…the specific interests of the individual purchaser of a motor vehicle vis-à-vis the manufacturer of that vehicle where that vehicle is equipped with a prohibited defeat device, within the meaning of the latter provision".

825. What this says is that it is not so simple as Mercedes wishes it to be – that the originating status of the FD carries the day. What one has here are the two types of mechanism working together. What matters is the origin of the obligation which is being protected. In this context it is artificial to regard the FD as the source. The FD is an overarching structure directed to a wide range of protective measures which are contemplated (and then gradually brought into being).

826. The only realistic analysis is that the obligation in relation to vehicle emissions is one which arises under the Regulation dealing with vehicle emissions. This is the backdrop to this entire case – if anybody asked any participant in this case what was being argued about the answer would be framed by reference to Articles 3(10) and 5(2) of the Regulation, with the FD making a small guest appearance in the background. This is also inherent in the passage from *QB* quoted above. The fact that it is the "*latter provision*" which is referred to indicates fairly clearly that it is Article 5(2) in which the protective purpose (from which actionability flows) is located. If it were the FD then "former provision" would have been used instead.

827. The argument at paragraph [517.2] of the Mercedes closing is topsy turvy. The fact that the CJEU begins in describing the ER as primarily aimed at ensuring a high level of environmental protection and only, having considered the FD, goes on to talk about the rights of individual consumers, most certainly does not mean that the right "*comes from"* the FD. It is possible for legislation to have more than one purpose – as the FD explicitly

does, being the overarching directive dealing with technical requirements for harmonisation with an explicit view to further "regulatory acts" to "*seek to ensure a high level of road safety, health protection, environmental protection, energy efficiency and protection against unauthorised use*".

828. In such circumstances it obviously makes sense that a single one of those purposes may only become apparent once one has looked at the broader scheme of which the legislation is part.

829. This same argument deals with the fact that the Advocate General noted that the ER was not directly aimed at the purpose of protecting consumers. As noted elsewhere and above a primary purpose does not prevent the existence of other purposes.

830. As for Ford's contention that the *QB* reasoning rests on a new post-IPCD reading of the FD – specifically Articles 18(1), 26(1) and 46 – to create a right to financial compensation for the purchaser of a vehicle which was not recognised by the CJEU or any domestic court in a case decided before IPCD, that is effectively another way of putting the same point. This is not a right which is grounded in the FD, but in the ER read, as it must be, with the FD. And as *Fry* establishes it is quite permissible for an English court to infer the purpose of an EU regulation by looking at the broader EU level scheme – including a directive – of which it forms a part.

831. The second broad category of attack is on *QB* itself: that it was in any event wrongly decided on this point. I have dealt with some such arguments above in relation to the earlier construction arguments. It will be apparent from that that I do not regard the case as being entirely without fault as regards what constitutes a defeat device. But is it faulty in this different regard – as to the consequences if there is a defeat device? I consider that it is not.

832. The first argument is that the decision is inconsistent with Case C-61/21 *JP*. *JP* concerned Articles 13(1) and 23(1) of Directive 2008/50/EC, the purpose of which was to reduce the emissions of harmful pollutants and to improve ambient air quality. Article 13 required Member States to ensure that the levels of various pollutants, including NOx, should not exceed specified levels. Article 23 provided that, where the pollutant limits were exceeded in a given area of a Member State, that Member State should ensure that an air quality plan was established to ensure that the limit or target value was achieved, and set out various requirements in relation to such air quality plans.

833. The question in *JP* was whether individuals were entitled to claim compensation in the event of a sufficiently serious breach of Article 13 and/or 23 by a Member State. The claimant in the main proceedings sued France, seeking compensation for ill health that he alleged was caused by poor air quality in Paris, in breach of the applicable limit values. The CJEU held that the obligations in question pursued a general objective of protecting human health and the environment as a whole, and thus did not confer actionable rights on individuals. The CJEU further noted that an individual affected by failure to put in place measures to meet the limit values must be able to require the national authorities, including by way of judicial review if necessary, to adopt such measures. However, it did not follow from this that such individuals must also have a right to compensation.

834. Mercedes says that the ER, like the Directive in *JP*, pursues environmental protection and puts in place a complex regulatory scheme to seek to achieve that and that the same conclusion should follow.

835. In my judgment this argument is misconceived, for a variety of reasons.

i) *JP* was concerned only with a directive;

ii) It took place entirely in a public law context which naturally did not involve considerations of consumer protection;

iii) The only obligation was on a Member State and related to general air quality;

iv) The submission is that the ER is exclusively concerned with environmental protection which, it is apparent from *QB*, is not right.

836. The second argument is that the private law right identified in *QB* is premised on there being "uncertainty" as to the validity of type approval (and by extension COCs), uncertainty which cannot apply in the UK given that CoCs remain valid even where TA has been withdrawn. I do not agree that the CJEU's point on uncertainty was linked only to the question of TA and CoCs. It is apparent from paragraph [84] of *QB* that it was the knock-on effect – primarily on selling a vehicle equipped with a PDD – on consumers that was the relevant uncertainty. Whilst the CJEU chose to connect that uncertainty with CoCs, it was, in my analysis, only a sufficient and not a necessary condition. The key point was that consumers suffer a loss when they are sold a vehicle which is defective. That is consistent with the Opinion of AG Rantos and also with the (pre-IPCD) decision in Case C-343/19 *Volkswagen*.

837. The third argument is that nothing in the ER suggests that it was concerned with pure economic loss – and pure economic loss is the only conceivable consequence of the "uncertainty" which results from the possible withdrawal of type approval and is thus too remote – as was the conclusion in *JP*. However this is an argument which essentially follows from the previous two arguments and fails as a result. *JP* was a very different case, predicated on a provision with a very different legal basis.

838. The fourth argument relates to Article 13. Mercedes submitted that the CJEU failed to consider the relevance of Article 13(1) which requires Member States to lay down penalties for infringements of the emissions regulation. The CJEU was clearly aware in *QB* of the effect of Article 13 and the provision is addressed explicitly at the end of the judgment, at [90]. That reference came after the CJEU had taken the slightly unusual step of sending a written question as to the nature of the various regulatory and criminal sanctions imposed at national level both under Article 46 of the Framework Directive (the correlate provision to Article 13) and Article 13 itself.

839. Further it is (as the Claimants pointed out) quite clear that this was an argument which Mercedes themselves made to the court in *QB*. This can be seen in the opinion of AG Rantos at [58] where the argument is recorded in terms in footnote 36. There are also plentiful examples of civil law claims being available when regulatory penalties are available and applied: it is a commonplace of "follow on" damages claim in the competition sphere that cartelists will have been investigated, found in breach of the

regulatory provisions and fined; but that does not stop the victims of the cartel from suing for damages.

840. The final argument raised by the Defendants is that because the FD extends over a vast array of construction requirements, if the *QB* analysis is right, then liability can arise in relation to any number of regulatory infractions. This is in my view a poorly thought out floodgates argument which rests on a misunderstanding of *QB*. It turns again on the assertion that the right identified in *QB* is "from" the FD. It is not. It is a case about no more and no less than Article 5 of the ER as read with the FD. It is certainly not saying that the breach of any construction requirement is capable of being actionable and there is nothing in *QB* capable of supporting that proposition.

841. Nissan accept the effect of *QB* but argues that it could be confined to the original purchaser because of the CJEU's conclusion that the individual rights arise from the provision of the CoC. While the obligation to provide a CoC arises only on production the CoC underpins the roadworthiness of the vehicle as regards all purchasers. It would also be odd if any right created excluded those who would not be able to rely on a direct contractual right of action, this making the right very much less useful.

Actionability if direct effect part 2: does EU law require the creation of a cause of action?

842. The second part of the argument was whether the creation of an Article 5(2) Eurotort is necessary pursuant to the principle of effectiveness given alternative remedies. However, as the Claimants pointed out, there is no need here of creation of a Eurotort. Breach of statutory duty is the tort relied on and that is not a form of action that is being created. All there is is the application of an existing tort in a conventional fashion to a piece of legislation that has EU origin and therefore requires an EU interpretation.

843. Were the question to arise, it is not, as Mercedes notes, a question decided by *QB*. The issue did not arise in *QB* because, as a matter of German law, a cause of action already existed under §823 BGB. Thus, the CJEU expressly declined to answer the fourth question referred to it, which asked whether EU law required that a purchaser has a claim for damages against a manufacturer in relation to the placing on the market of a vehicle containing a PDD.

844. Mercedes contends that the Claimants' submission that "*the EU provisions requires a claim*" goes too far. Mercedes concedes that it may require effective protection; but says that is not the same as requiring a claim for damages. It goes on to rely upon three authorities it says establish that a Eurotort will be required only in exceptional circumstances. In particular reference, was made to Case C-432/05 *Unibet* [2007] ECR I-2271 §§39-40, *R (United Road Transport Union) v SST* [2014] 1 CMLR 25 and *Burford Capital v London Stock Exchange* [2020] EWHC 1183 (Comm).

845. The first two authorities are not really on point. They have nothing to do with the question upstream of actionability, but deal with downstream questions directed at the question of whether or not the national procedural choices to give effect to the relevant EU right, which has already been recognised, violate principles of effectiveness or equivalence. *Unibet* is apparently seen as the most recent statement of the *REWE* principles.

846. The point therefore hangs on the *Burford* case. In that case the High Court considered, in the context of a Norwich Pharmacal application, whether the claimants had a "good

arguable case" for a freestanding action in tort founded directly upon Article 15 of Regulation (EU) No. 596/2014 (the Market Abuse Regulation). The claimants alleged that Art.15 introduced a "Eurotort", placing reliance on *Muñoz*. Baker J rejected that argument, on the basis that it did not even meet the good arguable case threshold. He reasoned (at §168) that "*the remedies provisions of MAR, and the exclusive role of national regulators (here, the FCA) in relation to them, seem to me a very significant obstacle for any such conclusion here*". On that basis, the Court did not accept the "*primary submission that there is a good arguable case … that Article 15 gives rise to a Muñoz euro-tort*".

847. The Defendants rely on this case as authority for the proposition that there is a "very high" bar for establishing a "Eurotort" and content that it illustrates that the existence of other (including regulatory) enforcement mechanisms will be "a very significant obstacle" to clearing that bar.

848. I do not accept that the case establishes this high bar. In that case Burford contended that breach of the regulation was effectively actionable per se and that there was no further test to be satisfied. The responsive submission was that the eurotort had to arise on the EU legislation upon its proper interpretation; that it is necessary to parse the regime and you still have to pass the *X v Bedfordshire* gateways in order to show that it was actionable (relying on the judgment of Teare J in an earlier case under the Market Abuse Directive, which had identical wording). The judge concluded, having examined the scheme as a whole, there was no such intent. Thus *Burford* is a fact specific conclusion as to the answer of *X v Bedfordshire* questions upon the facts of a particular scheme; and was reached without the benefit of any CJEU interpretation of the requirements of that scheme against questions of whether or not there is a protection of a private class or an intention of actionability.

849. Further as to the submissions on regulatory enforcement, Mercedes argues that the regulatory enforcement regime surrounding PDDs means that it is not "*impossible or excessively difficult*" to enforce the rights generated under Article 5(2) (and this limb of the arguments grants that such rights are generated by that provision). However this is not an answer. The right identified in *QB* is a right against the manufacturer. That is not and cannot be met by a regulatory enforcement regime, and any argument that a claim in contract suffices fails to account for any case in which there was, in fact, no contract, namely in the resale context.

850. The CJEU's judgments in *QB* and *CM* support the Claimants' submission that applying the *Muñoz* principles, a right of compensation for purchasers of vehicles which contain PDDs contrary to Article 5(2) ER is necessary to secure the full effectiveness of the relevant provisions of the ER.

Breach of contract

851. In the light of the above conclusion this issue becomes of less critical importance. The issue is whether the issue of breach can be established without more based on the materials and findings in this judgment. Does it follow, as night follows day, that if there is a PDD there is a breach of contract? This has been referred to by the parties as "the axiomatic breach" issue.

852. The question therefore is whether the Sample Vehicles in relation to which any PDDs are found breach the implied terms in the acquisition contracts (satisfactory quality and compliance with description) by virtue only of the fact that such breach necessarily follows from the PDDs. The argument essentially follows from the post-Brexit case of *DS* where axiomatic breach was found. At [54]-[55] the court held that:

> "a vehicle which does not comply with the requirements of Article 5 [ER] does not show the quality and performance which are normal in goods of the same type and which the consumer can reasonably expect, given the nature of the goods, within the meaning of Article 2(2)(d) of [Sale of Consumer Goods and Associated Guarantees Directive 1999/44/EC]".

853. The Claimants also point to paragraphs [95-97] as indicating that the breach is not a minor one.

854. To similar effect is the CJEU decision of *QB at* [81], [82] and [89]. As already discussed this authority is not binding on this Court, and the first question is the *Farley* one: should this Court regard itself as free to depart from this reasoning? As to this the position is slightly different to the earlier ER issues: the relevant EU law being applied in *DS* was Article 2(2)(d) of Directive 1999/44. As already noted (at [258]) pursuant to s.4 EUWA, rights, obligations etc. arising under Directives were not carried forward after IPCD unless they had been recognised by the CJEU or a domestic Court prior to IPCD. It is clear that the *DS* "axiomatic" right of action (i.e. a cause of action under which a PDD axiomatically amounts to a breach of the warranty of satisfactory quality without regard to any other circumstances) had been recognised prior to the judgment in *DS* and the reasoning in *DS* relied does not cite or apparently derive from prior CJEU authority on the point. It follows that this is a point which is "filtered out" by s.4 EUWA. The EU Law is not binding or *Farley*-persuasive.

855. This is not an issue on which one can look to *Crossley 1* because it was decided before *DS* in the CJEU and expressly did not consider the specific "axiomatic" satisfactory quality argument being considered here (as Waksman J noted at [251]) because it was raised too late (being inspired by the AG Rantos Opinion in *DS* handed down in September 2021), and Waksman J had held there was no point in resolving it before the CJEU ruled in *DS*.

856. It is fair to say that the breach of contract issue may be regarded as having been somewhat of a Cinderella argument in these proceedings. Although it has plainly been there, discussed in the EU authorities, and the subject of careful consideration (before the decision not to pursue it) in *Crossley 1*, the press of other arguments has meant that, for example, the suggestion by Waksman J that there might be a need for expert evidence on consumer expectation, has not been pursued by either party.

857. The allurements of the argument are evident. In practical terms this argument could avoid the need for a broader "all the circumstances" breach of contract claim, or the need for proof of deceit for CPUT. And legally it is not lacking a certain charm: AG Rantos's opinion in *DS*, which also found axiomatic liability under the implied warranty of compliance with description, points out with some force that "*an average consumer, who is reasonably well informed and reasonably observant and circumspect, can expect that the regulatory requirements for EC type-approval are satisfied*". The description relied on there was essentially the CoC, so also equally present in this case.

858. The Claimants contend that they can find the necessary "public statements" relevant to the satisfactory quality question and the "description" with which the Sample Vehicles failed to comply, on the type approval and CoC, and the producer signing up to the UK New Car Code, both of which public statements attest that the producer complied with the ER.

859. The Claimants also rely for the axiomatic argument on the nature of the PDD. Satisfactory quality expressly includes "*Fitness for all the purposes for which goods of the kind in question are commonly supplied*". They argue that once a PDD has been established the vehicle's ECS has reduced effectiveness in NDC, meaning it is not fit for the purpose of normal driving.

860. However I have no difficulty here in concluding that the axiomatic breach of contract argument is not an apt short cut. This is a case which is about statutory implied terms, which have a considerable history in English Law. Part of that history is that the Court is required to take into account all the circumstances including matters enumerated in the statutes s.10(2) Supply of Goods (Implied Terms) Act 1973; s.14(2) Sale of Goods Act 1979; s.9(2) Supply of Goods and Services Act 1982; and s.9(1) Consumer Rights Act 2015) bearing in mind that "*the reasonable buyer must be attributed with knowledge of all relevant background facts*". The concepts involved are distinct from the approach in Article 2(2)(d) of Directive 1999/44.

861. As Mercedes argued in their written Opening and Closing, this could cover a lot of ground (or as Waksman J put it "a welter of factual evidence"): ((i) public statements about the MCSVs; (ii) the price of the MCSVs; (iii) the risk or otherwise of any criminal offence hypothetically committed being prosecuted or otherwise enforced; (iv) the relevance or otherwise to consumers acquiring an interest in a luxury diesel vehicle of the emissions performance of their vehicle; (v) the relevance or otherwise to consumers that their vehicles might require a software update; (vi) the description of the MCSVs;; (vii) the actual impact of any PDD found, including whether the MCSVs really were liable to being taken off the road and the actual risk of this; and (viii) the extent to which consumers were aware, at the point of purchase, that they might have to install software updates in any event.

862. Of course the matters on which the Claimants rely would be part of this evidence; but they would not be all of it. There might well have to be evidence as to consumer awareness of or reliance on the New Car Code and as to the ability of vehicles to pass the NEDC test even with a PDD (as while "testing out" might be the wrong approach to establishing a PDD it might well have some impact on fitness for purpose). The Defendants also point to the not inconsiderable trade offs which a limited reduction in NOx emissions can have on other factors such as fuel economy, handling, noise, frequency of AdBlue refills.

863. It was against this background that the Managing Judges were in March 2024 sceptical about the inclusion of this issue, not closing the door to it but ruling that "*if it were to work at all, it would be a Pan-NOx issue (on assumptions reflecting the Defendants' best case)*". The fact that no assumptions were ever agreed is perhaps reflective of the accuracy of our prediction that "*the agreement of assumptions which made the issue meaningful may be difficult to achieve, and a considerable and expensive distraction when focussing on the progression of the factual and legal PDD issues is paramount*."

CONCLUSIONS

Summary of the overarching conclusions on the law

864. There is one agreed issue of law: There is no obligation for an OEM to meet emission limits outside the test cycle.

Article 3(10) issues

865. The relevant conclusions under this head are as follows:

i) The correct construction of the definition at Article 3(10) is that:

> "A defeat device is a device which senses one or more parameters of the test (including its boundary) and objectively operates with the purpose of causing the ECS to work more effectively when it senses that it is being subjected to a test cycle compared to how it works in out of test driving".

ii) It follows that for a defeat device to be found, there needs to be an intentional and/or impermissible purpose of causing the ECS to operate differently when it senses it is being tested.

iii) It is therefore unnecessary to calibrate "*normal driving conditions*" or determine the meaning of "*reduces the effectiveness*". Were that to be necessary:

a) The "*conditions which may reasonably be expected to be encountered in normal vehicle operation and use*" within the definition of a "defeat device" in Article 3(10) of Regulation 715/2007 are:

(i) The temperature window: 3°C to 30°C;

(ii) Altitude: 945hpa/ 600m;

(iii) Torque/Engine speed: Normal driving conditions do not extend beyond 95% of the range of the vehicle.

iv) "*reduces the effectiveness*" in this context is a concept that must be proved by the party asserting it. It is unlikely that desktop analysis can suffice, though it may provide input for a more broadly based analysis. Reduction in effectiveness is not easily ascertained in the context of the NEDC test. The least worst options for doing so are the Extrapolation Approach and the Percentage NOx Approach.

Article 5(2) issues

866. The Defendant has the burden of showing that the prohibition on DDs does not apply due to one or more of Article 5(2)(a)-(c), but thereafter, the Claimants have the burden of rebutting that case. If the Defendants establish a *prima facie* case that a device is needed to prevent damage (as that term is to be properly construed) and the Claimants wish to challenge that by reference to an alleged alternative technology which means that the

particular device is not needed, the burden of proving that technology and its availability shifts to the Claimant.

867. The scope of the "engine" in Article 5(2)(a) includes the ECS.

868. The "damage" which falls within article 5(2)(a):

i) Is damage to the engine;

ii) It is not necessary to show both protection of the engine from damage or accident, and safe operation of the vehicle. Either one of the conditions is sufficient;

iii) It is necessary (in line with *CLCV*) that the damage be "sudden" or "exceptional";

iv) Damage relates only to "*immediate risks of damage which create a specific hazard when the vehicle is driven*".

869. "[A]ccident" in the context of Article 5(2)(a) means an unforeseen, sudden event that results in damage or danger to the engine.

870. The "*safe operation of the vehicle*" in the context of Article 5(2)(a) relates to the safety of the vehicle when driven, including other drivers, road users and potentially the safety of passers-by and bystanders. It requires a focus on significance and immediacy; it does not encompass generalised product safety or engine wear and tear.

871. The Article 5(2)(a) exception can apply to a device that operates for most of the year.

872. The "need" does not exist only where at the time of Type Approval no other technical solution makes it possible to avoid damage or accident and risk. However it will be a relatively high bar into which the nature of the device, the risk which it meets, the seriousness and likelihood of that risk will usually enter. Costs of research, safety and so on may be relevant to the determination but are almost never determinative.

873. Article 5(2)(b) permitting the use of a DD in circumstances where "*the device does not function beyond the requirements of engine starting*" is limited to the initial ignition of the engine.

874. Article 5(2)(c) must (on the primary/CRDD analysis be construed narrowly. "substantially" means that most of the conditions in which the functionality operates must be present in the test, and the conditions must also apply in the test for a "sufficient duration", which means they will not be substantially included if they only arise momentarily – it remains possible that they could occur for a short period (for example if they relate to conditions which occur only for a short time).

<u>Actionability and Breach of Contract</u>

875. The statutory scheme properly construed requires the creation of a private law right of action.

876. The axiomatic breach of contract argument fails. Arguments on breach of contract will require to be argued, if pursued in the light of the prior answer, on the basis of full evidence.

Summary of the findings on individual cases

877. The net result of this analysis is that on whichever analysis of the relevant provisions is pursued, the ambit of the claim is much reduced. As will be explained in greater detail in Part 2 of the judgment:

i) The (limited) CRDD arguments succeed only in part;

ii) Based on the contingent (template plus NDC findings) analysis which I have outlined many of the PDDs alleged do not succeed;

iii) On the basis of the Claimants' fuller case (their NDCs) some PDDs would still fail on the basis of failure to prove RIE;

iv) Where they do succeed the justification arguments substantially would fail on the basis of the evidence before me, and the approach taken above (the justification which might require reconsideration as a question of balance if a different view were taken as to the Article 3(10) definition and/or the NDC conclusions).

878. A table summarising the findings below appears at the end of Part 2 of the Judgment.

Mercedes

879. On the Mercedes defeat device allegations:

i) CTS is a CRDD. If a PDD, RIE is not established;

ii) Base Maps: No CRDD alleged. RIE is not established;

iii) Cooler/Bypass: No CRDD alleged. RIE is not established;

iv) Air temperature: No CRDD. Subject to RIE, some of the vehicles contain DDs; but no RIE established;

v) Engine Temperature: No CRDD alleged. RIE is not established;

vi) MBC1 Idle: No CRDD alleged. No PDD. RIE is not established;

vii) Engine Start: No CRDD alleged. No PDD. RIE is not established;

viii) Atmospheric Pressure: No CRDD alleged. No PDD. RIE is not established;

ix) SCR Dosing: No CRDD alleged. No PDD. RIE is not established.

Ford

880. On the Ford defeat device allegations:

i) Torque/speed: DD allegations are not established, and in any event no RIE was evidenced;

ii) Temperature window: there would be a DD (subject to RIE being established) on FC5 and FD3 only; however no RIE is established;

iii) Atmospheric Pressure window: there would be a DD (subject to RIE being established) on FD3, FD1 and FC6 only; however no RIE is established;

iv) LNT: not a CRDD, not a DD on template, but a DD on the Claimants' case;

v) SCR: No CRDD alleged. No PDD. RIE is not established;

vi) 6th gear: No CRDD alleged. No PDD. RIE is not established.

PCD

881. On the PCD defeat device allegations:

i) Split mode is a CRDD. It would also be a DD. RIE is established;

ii) Atmospheric Pressure: No CRDD alleged. No PDD. RIE is not established;

iii) Temperature: No CRDD alleged. No PDD. RIE is not established;

iv) Torque/Speed: No CRDD alleged. No PDD. RIE is not established;

v) Euro 6 Combustion modes: No CRDD alleged. DD subject to RIE (the thermal window element of the switch between combustion modes). RIE is not established;

vi) SCR: is not a CRDD. Would not be DD on template approach, but a DD on Claimants' case. RIE (marginal) established.

Renault

882. On the Renault defeat device allegations:

i) Temperature: No CRDD alleged. Partial DD (RC2 pre-update and RC3). RIE established (RC2 pre-update and RC3).

ii) HT Cutoff: (RC2 only) No CRDD alleged. No DD. RIE is not established;

iii) Torque cutoff: No CRDD. DD. RIE is established;

iv) Warm up 4th/5th gears (RC2 only): No CRDD alleged. DD. RIE is established.

v) Correction factor: No CRDD alleged. DD. RIE established, but Article 5(2)(c) applies in respect of (RC3);

vi) Delayed start of LP EGR: No CRDD alleged. No DD. Article 5(2)(c) subject to RIE (the thermal window element of the switch between HP/LP EGR). RIE is not established;

vii) Atmospheric pressure (RC2, RC3 only): No CRDD alleged. No DD. RIE is not established;

viii) LNT: is not a CRDD. No DD. No RIE.

Nissan

883. On the Nissan defeat device allegations:

i) DD (NC1, NC2 original). RIE established ;

ii) Low temperature cutoff: No CRDD alleged. No PDD. RIE is not established;

iii) HT Cutoff: No CRDD alleged. DD (NC1). RIE is established;

iv) Atmospheric pressure: No CRDD alleged. No PDD. RIE is not established;

v) Correction factor: No CRDD alleged. DD . RIE established;

vi) Torque cutoff: No CRDD. DD. RIE is established;

vii) Delayed startup: No CRDD alleged. No DD on template approach, DD on Claimants' case subject to RIE. RIE is not established;

viii) LNT: is not a CRDD. No DD. No RIE.

PART 2

884. This part of the judgment deals with the individual defeat devices alleged. A vast amount of material and submission was addressed to the detail of the defeat devices. It is simply not feasible to address every point raised and in the light of the conclusions set out above on the main legal issues, it is largely unnecessary to do so.

885. What follows therefore is a relatively brief treatment of the issues which arise for each CSV, designed to enable the parties, familiar as they are with all the detail, to understand the views taken on the issues as they pertain to (i) the CRDD allegations, and (ii) the main fallback arguments. It is unlikely to be comprehensible to a general reader.

THE MERCEDES CSVS

CSVs and summary

886. Mercedes-Benz ("Mercedes") is a luxury motor brand, previously known as the Daimler Group. It sells diesel vehicles in numerous regions and countries, including the UK, US, Japan and Korea.

887. There are four Mercedes CSVs:

CSV		Euro	Model	Engine	Year	ECS technologies
MBC6		6	M-Class (ML 350 Bluetec 4 Matic)	OM642	2012	HP EGR & SCR
MBC1		5	E-Class (E220 CDI)	OM651	2014	HP EGR
MBD1		6	C Class (C220d)	OM651	2017	HP EGR & SCR
MBD6		6	GLC 350d 4MATIC	OM642	2017	HP EGR & SCR

888. The Claimants' case concerns three groups of PDDs. It is alleged that:

i) MBC1 contained something called a Coolant Temperature Setpoint Manipulation Device ("CTS"). The Claimants allege that the CTS is a CRDD and rely on the fact

that it has been held to be a PDD in German Court decisions and by the KBA. The essence of the alleged "cheat" is that in the NEDC, it works artificially to prevent the engine warming as quickly as it does off-cycle, maintaining engine temperature below normal operating temperature. The result – and the Claimants say, the aim - was to ensure that EGR Corrections reducing the EGR rate by reference to engine temperature did not activate during the NEDC test. The effect was that off-cycle emissions were higher because the CTS did not operate to delay the activation of the EGR Corrections. The Claimants contend that this is a particularly significant PDD because although this is only in one CSV, it is present in more than half of the OM651 & OM642 Sample Vehicles, and at least half of the overall cohort.

ii) There are a portfolio of EGR DDs alleged

a) Each CSV is also alleged to have a thermal window which operates as part of the CTS. Those windows vary as set out in the summary section above. Some of the updated windows are not alleged to be PDDs;

iii) It is also alleged that all CSVs have an EGR Rate Manipulation Device which applies materially lower EGR base rates at torque and engine speed combinations that are regularly encountered in NDC, but not substantially included in the NEDC test. Those base EGR rates are then further reduced by a series of corrections ("EGR Corrections").

iv) Third, MBC6, MBD1 and MBD6 ("SCR CSVs") contain SCR-related PDDs. The crux of the Claimants' case is that the SCR was purposely designed to reduce AdBlue dosing off-cycle, to conserve reagent, with the effect that the vehicle was less effective at treating NOx.

889. The Claimants contend that Mercedes' motivation to install the PDDs was driven by two primary concerns. The first concern was fuel and AdBlue consumption. They say that Mercedes wanted (i) to reduce fuel consumption off-cycle (ii) for the SCR, to reduce AdBlue consumption to avoid: AdBlue refills before recommended service intervals, with all the inconvenience this entailed; and / or larger AdBlue tanks. The second alleged primary concern was to produce luxury, capacious, agile cars for the high-end Mercedes brand. This concern is said to be relevant to EGR, which reduces engine power and acceleration/"sportiness" whilst increasing noise and vibration.

890. Accordingly it is alleged that Mercedes' early design strategy was to calibrate their cars to the NEDC, treating off-cycle emissions as unlimited. However, following the VW scandal in 2015, Mercedes planned to release a series of updates to its Euro 5 and 6 diesel fleet. They had outlined the "update packages" they planned to release by December 2015, that is within just 2-3 months of the VW scandal breaking.

<u>The evidence</u>

Experts

891. There was predictably a vibrant debate as to which of the mechanical engineering experts I should prefer. As I have already indicated the nature of the case is such that it is almost inevitable that the line between expert opinion evidence and belief based on subjective interpretation becomes eroded.

892. Neither expert was sufficiently distant from the fray for the court to be able to have the fullest confidence in their neutrality. Mr Smithers had a lengthy history of acting for the claimant side in disputes of this precise nature and indeed indicated that he had gained much of his relevant expertise from those appointments. Mr Day's background – as a senior employee of Ricardo and deeply involved in calibration or Euro 5 and Euro 6 vehicles for manufacturers by contrast came to this role thoroughly imbued with the manufacturer side ethos and perspective, such that it was understandable that the Claimants urged caution as to his independence and vulnerability to conflict of interest.

893. Overall and as explained further in detail below the evidence of Mr Day was more impressive than that of Mr Smithers.

894. In the first place Mr Day simply was more expert in the relevant discipline. Mr Day's expertise could not be denied, and the Claimants confined their criticisms of his evidence to his approach to answering the questions and his alleged lack of independence. Mr Smithers is not a mechanical engineer but a chemical engineer, who has segued into being a professional expert witness. He has no mechanical engineering qualifications. He has no relevant publications. He has no experience of developing or calibrating EGR or ammonia based SCR systems. He had limited automotive experience in the context of a company which manufactured exhaust gas aftertreatment systems for retrofitting to heavy duty vehicles. On a number of occasions he indicated that he was not competent to answer questions of mechanical engineering expertise, or sought to answer them by reference to derivative materials such as Guidance or case law.

895. Further, the impression which Mr Smithers conveyed was that he had not wholly imbibed the ethos of the Part 35 expert process and that he was very keen to move discussion onto the bits of evidence which he wanted to talk about. He had a tendency to search for any qualification rather than to accept fairly obvious propositions if he sensed that the concession was contrary to the Claimants' case. His evidence was marked by some notably long pauses before he would accept even the most obvious proposition – the pause which preceded his acceptance that higher engine loads can be encountered at any time of the year was one which stuck particularly in the memory. And on occasion he maintained issues well beyond the bounds of credibility – as in the case of his sticking to the line that oscillating speed between 60 and 70 mph every 10 to 20 seconds was something that would happen "very frequently" in real driving. That was a proposition which I indicated then would rather be at the bad luck end of the spectrum than common, still less "very frequent".

896. That is not however to say that Mr Day's evidence was perfect, or that it can escape being carefully interrogated. It is fair to say that his own historic approach was to some extent indirectly in question: he for his employer had in the past made some the engineering judgments involved in calibrating similar vehicles in a broadly similar way. It is only to be expected that even outside direct challenge there would be a tendency to default to defence of the approach. However I found him a sensible and helpful witness and reject the invitation to conclude that he was neither credible or reliable. I concluded that he was both – but subject to some qualification.

The implications of the lack of factual witnesses

897. The Claimants have contended that so far as Mercedes is concerned, I should draw fairly extensive adverse inferences from the lack of factual witnesses. Reliance was rightly

placed on *Royal Mail Group Limited v Efobi* [2021] UKSC 33, [2021] 1 WLR 3863 and I was invited to draw the following adverse inferences based on Mercedes' decision not to call factual evidence and/or its failure to adduce disclosure explaining the contemporaneous reasons for particular calibrations:

i) In Euro 5 Mercedes' calibration philosophy was to maximise EGR use to the extent required to pass the NEDC with some "headroom" whilst still generating optimal fuel consumption figures on the NEDC test; but substantially to reduce the use of EGR outside the NEDC zone not solely for safety concerns but primarily to maximise real world fuel economy; to reduce NVH; to increase sportiness/performance to a level consistent with the Mercedes marque, o long as NOx emissions off cycle were controlled to the extent required to obtain 3 stars on the Swiss Touring Cycle test;

ii) Mercedes took a conscious and deliberate decision to use less EGR in its EU vehicles than in the same or equivalent models in the US (where the EPA was in particular exacting in its examination of altitude and temperature-based reductions of EGR), in order to maximise fuel economy and sportiness of its vehicles in the EU, as: (i) the price of diesel (and the consequences of higher CO2 consumption in terms of taxation or attractiveness to potential customers); and (b) the sportiness of its cars were stronger competitive considerations/constraints in the EU;

iii) Mercedes at all stages in Euro 5 had ample spare capacity in their extant DPF regeneration schedule to increase the use of EGR without increasing the regularity of DPF regeneration;

iv) This led to the instruction to IAV and others involved in recalibrating the Mercedes vehicles for the "voluntary updates" pressed for by the German Authorities not to increase the use of EGR beyond that consistent with the ki number remaining unaltered/DPF regeneration remaining unchanged in frequency. Mercedes did not investigate or contemplate any updates which would have resulted in greater EGR use at the price of increased DPF regeneration and/or a consequential amendment to type approval;

v) Mercedes intended to use Dual Dosing functionality in order covertly to achieve its corporate goal, in the US and then in the EU, of reducing the AdBlue consumption implied by using the SCR at the efficiency obtained (after warm up) on the NEDC (for shortly after) using the logic of the Fill Mode so that vehicles would not require a refill of AdBlue before recommended service/oil change intervals ("Refill Range");

vi) The calibration of each of the Bits (and the entry and exit conditions underpinning them, including hysteresis choices) used in the Mercedes SCR – and the correction factors that applied once a Bit was triggered – were all designed to trigger Online Dosing (and its consequentially lower dosing) in scenarios where high AdBlue consumption was anticipated from measured conditions (whether by reason of the nature of those conditions, or by the parallel derating of EGR in those conditions) because of high engine out NOx; and to reduce the consumption of AdBlue in such an extent as to attain the Refill Range;

vii) It was no part of contemporaneous calibration philosophy or choices to attune such Bits or the consequential correction factors to address either actual or potential problems of: (i) model/sensor inaccuracy; or (ii) ammonia slip;

viii) Had Mercedes had genuine concerns about ammonia slip it would have specified the larger SCR catalyst volumes previously used in the US or an ASC. But it had not such concerns, not least because: Fill Level logic and the adaptation functions already addressed potential slip issues; and it was limiting AdBlue consumption by the use of Online Dosing, including in those situations (high or rising SCR temperature leading to thermal slip) because such high temperatures were also consistent with high loads, and so high engine out NOx production and AdBlue consumption;

ix) Had Mercedes genuinely believed that Dual Dosing had been calibrated to address NH3 slip, they would have disclosed Online Dosing to the EPA as an AECD.

898. Merecedes' response was fairly terse contending:

i) The inferences sought are too broad and unspecific;

ii) Mercedes can hardly be said to have fallen short on disclosure. The disclosure exercise was extensive, had cost Mercedes £7 million and led to the disclosure of more than 670,000 documents for this trial;

iii) Many of these documents were documents from or held by calibrators and engineers – i.e. the individuals who were responsible for the development of the CSVs' firmware and the calibration of the engines;

iv) The witnesses whose absence is complained of are largely the same people whose documents have been disclosed;

v) The Claimants are complaining because the disclosure exercise was a failure – only 150 documents (0.02% of the outturn) have even been included in the bundles;

vi) The complaint as to absence of witnesses' is "cakeism" of the first order when against other Defendants the Claimants ask the Court to discount their live witnesses testimony because "*There is no substitute for the contents of contemporaneous documents, which reveal the real targets and calibration considerations, the real objectives for devices, and the extent to which real concerns about safety arose*";

vii) As regards SCR in particular the complaint relates to the absence of witnesses to address competition disclosure, when competition is not part of the issues for this trial.

899. The question of whether to draw an adverse inference is best considered in situ – in relation to the issue to which it is said to relate. Breadth, relevance and other evidence can best be judged in that way.

MBC1 CTS

900. CTS stands for "coolant temperature setpoint". This is a coolant based device. When engine coolant is too hot, the cooling system actively cools it by channelling the hot coolant through a radiator. A wax thermostat prevents coolant flowing to that radiator until the coolant has warmed up. The wax will melt naturally when the engine reaches 95°C, allowing coolant into the radiator to be cooled from that point onwards.

901. The Claimants' case is that the CTS device only activates under defined cumulative operating and environmental conditions tailored so that the CTS will activate in the NEDC but not in other NDC. As for RIE, CTS changes the coolant setpoint as temperature conditions move away from a narrow "on-cycle" range, with corresponding increases in engine-out NOx.

902. In summary:

    i) The CTS engages and lowers the engine setpoint temperature to 70°C when: (a) the AAT is between 15°C and 35°C (i.e. close to the NEDC temperature range); (b) the IAT is between 15°C and 50°C; (c) the oil temperature is below 81°C; (d) the engine speed is below 3,000 rpm and injected fuel below 51 mg/str; and (e) atmospheric pressure above 800 hPa;

    ii) In addition, the CTS works on a timer, the length of which depends on the engine start temperature. For an engine start temperature of between 20ºC and 30ºC, the timer is set for between 1,300 and 1,600 seconds, that is a duration just longer than the 1,180s of the NEDC.

903. The starting point of the debate was originally about whether the conditions for operation of the CTS will all be met at the start of an NEDC test and throughout much, if not all of the test itself; but will very rarely be met outside the NEDC Zone or in it for a vehicle that starts hot. In opening the Claimants suggested that the conditions would not be met outside the test. However it is now accepted that (as both Mr Smithers and Dr Heitz accepted), the CTS will operate in some limited NDC outside the NEDC Test, i.e. a cold start in the NEDC Zone without high loads. The Claimants now rely heavily on the inability of Mercedes to explain the purpose of the timer, and the absence of any factual witness.

904. Mercedes says that there is no CRDD. It submits that:

    i) This is not a "Jekyll and Hyde" device. From a software and calibration perspective, Dr Martens has confirmed that if a given set of conditions (of load, speed, temperature etc.) is encountered the ECS of each MB CSV will demand the same coolant setpoint whether those conditions are encountered in the test or on the road;

    ii) The Claimants ignore how the CTS operates in reality ignoring the breadth of the actual activation conditions. It is not correct that the conditions will only or almost only be encountered in the NEDC;

    iii) The operation of the device does not in any event materially affect emissions.

905. There have been findings, upon which the Claimants rely, that the CTS was a PDD. On 4 April 2019, the KBA wrote to Mercedes stating it considered the CTS to be a PDD. It issued an MRD on 21 June 2019 finding that the CTS was a PDD. The KBA expressly noted this delayed the activation of EGR Corrections and took the view that this was "*not a test bench detection, but a recognition of the test situation for type 1 testing*". Those findings are not binding on this Court. The CTS Recall Decision was retrospectively annulled by the Schleswig-Holstein Administrative Court by Order dated 27 November 2025. As the Court held in the KBA Judgment, the effect of a successful appeal against KBA Recall Decisions is to render them null ab initio. The correct way to proceed is to consider first the evidence adduced in this case.

Test alignment and CRDD

906. The first point as regards the device is to consider the factual basis – was it, as the Claimants contended, aligned to the test?

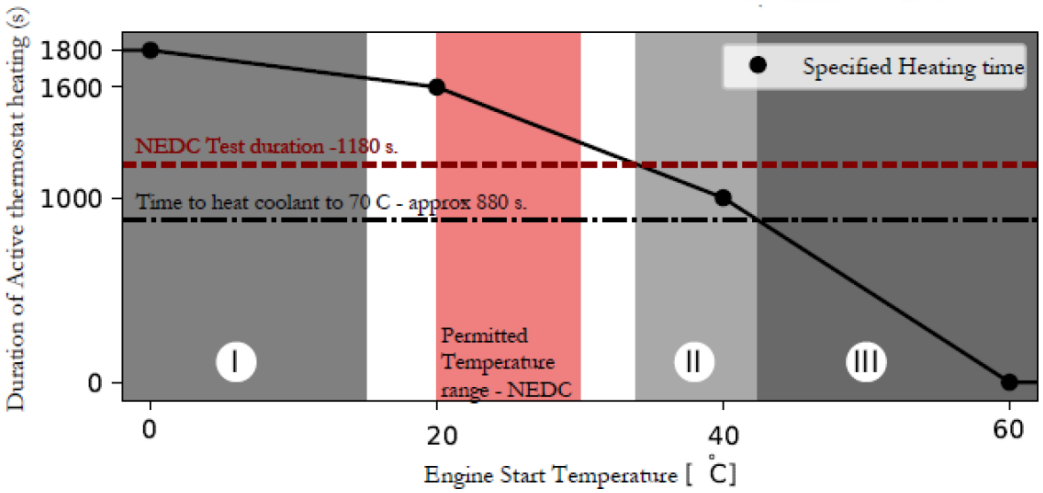
907. Mercedes have disputed this, noting that:

    i) Timer: if the starting temperature is 20°C, the timer stops after 1,600 seconds, which is a full seven minutes after the NEDC test has been completed and over one−third of the duration of the test is not "shortly after" the end of the test.

    ii) Temperature: a window of 15°C -35°C is self-evidently broader than the NEDC 20°C -30°C range. Thus for MBC1 IF the CTS activated in two non-NEDC tests, including one on-road test, the latter having AAT in a range between 16°C and 19°C;

    iii) CTS operated in the same manner in the same conditions whether those conditions were encountered on or off the test bench and was active in various conditions that are not encountered during the NEDC test.

908. As to the timer issue, Mercedes' point appears to be accurate, but the focus on the single temperature point is notable. The table below demonstrates the point made in response by the Claimants – although the caption in the pleading where it appears does not argue tailoring to the test, but simply that it is there "*to demonstrate that PDD device remains active throughout NEDC test*", (the CRDD issue was then live and aspects of this graph were not admitted by Mercedes in the corresponding pleading).



909. What can be seen clearly from this chart is how much closer to the limit the timer comes over the course of the temperature window, so that at 30°C the timer was down to very little above the length of the test. Also, the diagram illustrates nicely how the temperature and timer windows co-operate, so that a very limited window for its operation does come close to the test parameters.

910. Similarly the point as to temperature was made good by some of the on road activation of the device in NDC conditions. Thus it is true that the CTS activated in the 21 May on−road test where the temperature was between 16°C and 19°C. But at the same time and echoing the diagram, the testing did not show much operation outside the test at all.

911. As for the effects of the device, it would, at least on a desktop analysis be expected that this device would reduce NOx while it operated (i.e. in the NEDC test. This much is apparent from the Claimants' case on RIE outlined further below.

912. Based solely on the parameters and testing therefore the CTS raises a question, particularly given Mr Day's acknowledgement that it was "*atypical*", but there is no "*smoking gun*". Other evidence as to intent and design therefore becomes relevant.

913. The Claimants relied on a document dating from when Mercedes planned to remove the CTS as part of the update program, which stated that the effect was that coolant temperature "*is no longer kept at 70°C during the 20°C NEDC*". Again this appears to indicate a likelihood that the device was designed for that purpose, but cannot be said to be pellucid, given it brevity.

914. It was for this reason that the Claimants here relied heavily on adverse inferences. They submit the same inference should be drawn as was drawn by the KBA: that Mercedes have chosen CTS activation conditions which match the boundary conditions of the NEDC Test, that they were unable to explain the timer to the KBA and that the failure to call a witness counts against Mercedes. This was not one of the adverse inferences specifically listed in the relevant section of the Claimants' Closing, but as a specific inference should be considered.

915. The Claimants contended that they would have wanted to cross examine witnesses (Messrs Arndt and Paule) as to the true purpose of CTS in the absence of documents showing relevant calibration decisions or risk assessments.

i) Mr Arndt was a manager who worked on the four CSVs, was responsible for the January 2012 Arndt Presentation and internally distributing information on Mercedes' worldwide emissions performance. Mr Arndt does not appear to have had any part in designing the CTS device.

ii) Mr Paule was involved in the development of the concept of Online Dosing (and the activation Bits), including the meetings between the Cartelists. Further, Further, he worked on MBC6 and MBD6 between 2009 – 2011, and was the co-ordinator of the update programme. He seems to have been more relevant to SCR.

It therefore does not appear likely that either of these witnesses would have relevant evidence to give on this issue. I reject the invitation to draw adverse inferences in this regard.

916. The Mercedes case is that the inference of nefarious intent should be rejected, because there was a good explanation. They point to the evidence of Mr Day that a 2019 MB presentation demonstrated the benefits of the CTS device – it showed that development work had been done to ensure that there are benefits of the "*sweet spot*" for NOx and PM emission reduction at 70ºC coolant temperature across a larger range of torque. There was considerable cross examination on this topic, the upshot of which was that there were good reasons to prolong a sweet spot if possible, but that holding on to it for too long would be likely to have negative effects: "*if you hang on to that sweet spot doggedly, you'll end up with further problems of different types as well*".

917. I conclude that there may be some justification for a limited amount of tailoring temperature to sweet spots, but I would not be minded to conclude that this was the motivation here: Mr Day's argument here smells somewhat of the lamp, in circumstances where there does not seem to be any contemporaneous documentation to support that approach. There are no calibration guides, discussion documents and the like explaining why the calibration landed at 15°C and not 13°C or 12°C – or indeed the significance of the timer. Further when asked to explain it by the KBA Mercedes were apparently unable to do so and the document recording the explanation makes no reference to "sweet spots" but rather to engine protection. This explanation was rejected by the KBA (whose view was "*the functionality is used to reliably meet the NOx limits in the NEDC"*) given that Mercedes so rapidly managed to get rid of this device.

918. Therefore in my judgment a conclusion that this is a CRDD (boundary device) is justified. I have in mind here:

i) The very specific outlines of this particular device: two key parameters both set very close to the limits of the NEDC, and co-operating in practice so as to mimic NEDC limits with a small margin. These are far too close to the NEDC to be credibly susceptible of this explanation. As the Claimants put it in closing: "*it would be a bizarre coincidence if a device which closely matches the NEDC conditions in terms of both temperature and length of its operation also happened to be calibrated to the safety margins of its operations. That is simply implausible.*"

ii) The operation outside NEDC appears marginal;

iii) The explanation now given of "sweet spots" is nowhere in the contemporaneous documentation and was not given at the time;

iv) The near contemporaneous documentation suggests that Mercedes staff perceived the function of the CTS as being one geared to the NEDC.

919. This is not a conclusion of intent to cheat the test and a classic CRDD; this is a boundary device, quite likely a case of optimisation and parameterising to the test with some other benefits also in mind – but veering over the dangerous boundary I have noted above. The device was calibrated to ensure vehicles passed the test, it would operate very rarely out of test. There was no evidence of a non-test related reason for its existence to displace the inference from the other facts. Mercedes may be unlucky in this conclusion, but the evidence is striking.

920. Mercedes tacitly acknowledged the difficulties with this device in their decision to remove this device from affected vehicles as part of an expedited set of post-Dieselgate updates in December 2015. In doing so Mercedes noted that coolant temperature *"is no longer kept at 70°C during the 20°C NEDC*" suggesting that the author at least thought that this is what the CTS was doing.

921. Given the conclusion on CRDD the question of RIE does not arise. However the tension below between expected and actual results, and the difficulties involved in establishing RIE but configuring a testing regime which "bites" is of interest beyond the requirements of considering a fallback analysis.

<u>If no CRDD, then DD?</u>

922. There are many NDC in which the CTS does not operate: for example when the AAT is below 15°C; when starting the car with a warm engine; at high loads, such as accelerating to join a high speed road. Therefore, there is an element of design operating to modulate the EGR functionality and the first part of the wider DD definition is engaged.

923. The next issue is whether the CTS on the evidence has the effect of reducing engine out NOx such that there is an RIE when it does not operate.

924. The Claimants noted that Mercedes' pleaded case on the effect of the CTS is:

> "… the CTS operated to reduce the engine coolant thermostat setpoint temperature in MBC1 and that, in doing so, it had a cooling effect (on, *inter alia*, combustion temperature and exhaust gas temperature) which, inter alia, reduced NOx emissions".

925. Therefore, they say, Mercedes' own case is that the CTS reduces NOx emissions when it activates, and, by logical extension, does not reduce NOx when it does not operate. The Claimants also contend that lower temperatures will both lead to lower peak combustion temperatures and also delay the onset of EGR downrates.

926. The starting point therefore is that a desktop analysis suggests that the CTS will reduce the effectiveness of the ECS. The points above are supplemented by others:

i) The expert evidence that running the engine at a lower temperature will result in lower peak combustion temperatures and less NOx produced as a result.

ii) Analytically by keeping the temperature of the engine below 80°C (which is the end effect of the device), the CTS will in turn delay the activation of various downward EGR rate corrections that are based on engine temperature.

927. Mercedes' case however relies on the results of the testing programme.

928. First, Mercedes says the CTS Deactivation Test had a CCF of 1.06 (which, Mr Smithers agreed, is within the range of test-to-test variability). Mercedes contends that NOx emissions are slightly higher than the Emissions Limit only because, in order to deactivate the CTS, it was necessary to hold the engine at 3,200rpm for 5 continuous seconds; the second-by-second data shows that significant additional NOx was emitted during this 5-second period, causing the overall emissions result to exceed the Emissions Limit by 6.4%. Were this test robust it would be quite helpful. However aside from the uncertainty produced by the holding at high revs, there is evidence which suggests that the CTS did kick in at 650 seconds (red line in second chart) holding coolant temperature down for about 2 minutes. The deactivation activity also apparently disabled the stop/start function, adding another variable.

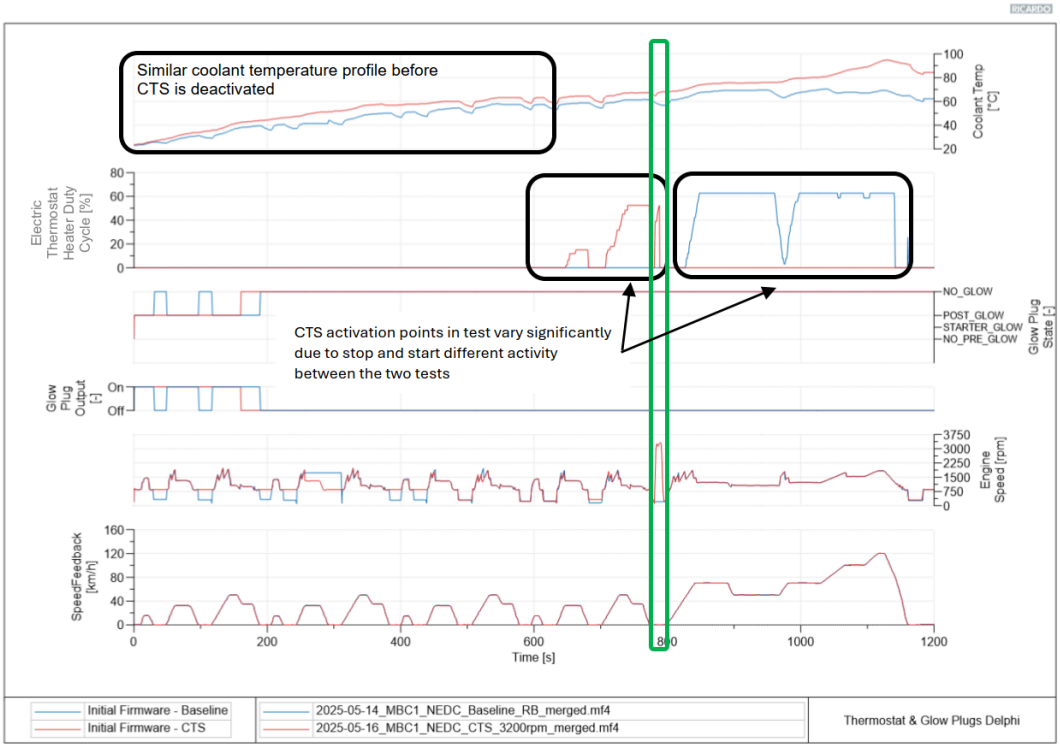


Figure 10: MBC1, NEDC Baseline vs NEDC CTS Deactivation Test, CTS Activation Variability, Initial Firmware

929. A second issue arising from testing is that for MBC1 UF (which does not have a CTS device) the coolant temperature in the NEDC only exceeded 80ºC (the temperature which would trigger the MBC1 IF Engine Temperature Correction) at 1,145s (near to the end of the test of 1,184s). This timing is significant. The Claimants point to the fact that this is after the last significant acceleration and assert that but for the CTS the Engine Temperature Correction would have activated earlier - because the engine temperature would not have been controlled by the CTS 70°C setpoint for a period of around two minutes. Positing that the Engine Temperature Correction had applied two minutes earlier, they say it would have been active during the two fast accelerations of the EUDC with a significant impact on emissions (on top of the increased NOx emissions caused by

the generally higher engine temperatures resulting from the CTS not being active for two minutes). Mr Day accepted that the NOx would likely increase if the Engine Temperature Correction started to apply earlier in the NEDC, but that the extent of the increase would depend on how much earlier it applied.

930. This appears entirely logical. However it is apparently contradicted by the facts. 1145s was in fact the same point that MBC1 IF exceeded 80ºC in the CTS Deactivation Test. This appears at first blush to demonstrate that the CTS did not delay the operation of an Engine Temperature Correction in the NEDC tests. However the dangers of relying on that conclusion become apparent when one bears in mind the effect of the CTS triggering for 2 minutes from 650 seconds.

931. Mercedes contended that Mr Smithers' challenges to this result were speculative and, on the hoof, and that the cross examination of Mr Day, though robust, did not shake his evidence that the distinction between the operation of the vehicle with and without the CTS device was illusory. However Mr Day's evidence did not really deal with this aspect, focussing rather on explaining the 1.06 correction factor.

932. His other point was that Figure 9 of Appendix 2 to RD1 shows that NOx emissions levels in the short period when the CTS activated in the CTS Deactivation Test were the same as in that period of the NEDC Test, when the CTS did not activate: plot 1 shows the blue and red lines mapping each other in the period immediately prior to the green box when the engine was revved in the CTS Deactivation Test. This is said to show that there is no effect on engine out NOx

933. The Claimants also relied on testing done nearer the upper end of the NEDC range at the instance of the KBA. The results indicate that without the CTS the vehicle passed at 23ºC, but failed at 28ºC. They also appear to show engine and coolant temperature rising faster. At the same time the EGR rate trace is not markedly different. These of course were tests which the experts did not have full visibility on. They related to an E200 class vehicle with an OM651 engine (MBC1 is an E220 class). The vehicle considered in this presentation had manual transmission and different engine power (100 kW compared to 125 kW in MBC1), which alters the hardware, emissions profile and how the vehicle heats up, and consequently the impact of the CTS on emissions. Conclusions arising from the testing of one vehicle cannot simply be applied to a vehicle with different hardware and calibrations.

934. The net result is that the evidence on RIE is extremely unclear. Contrary to the logical expectation, it is not clear that the CTS did create a more effective performance of the EGR system such that performance out of the conditions in which it triggered was an RIE. The balance falls very slightly on the side of Mercedes in that the testing does not demonstrate RIE. The case on CTS as a non-CRDD PDD therefore fails on that point.

935. Had the opposite conclusion been reached it would have been necessary to consider Mercedes Testing Out arguments. I have already determined that the Testing Out approach is not sound. Therefore this could not save the Mercedes device. To the extent necessary I would also accept the submission that it is not sufficient to "test out" a vehicle at (say) 23°C, to escape the conclusion that there is an RIE. It would be necessary to establish that the CTS did not have an effect at the higher temperature boundaries – say 28°C, rather than cherry picking a spot where the testing did work.

936. It is worthy of note that wherever one gets on this the evidence does not suggest that any RIE was large.

Article 5(2)

937. As for Justification, the Mercedes case on this is not remotely persuasive. Mr Day's explanations of the reasons why the device might have benefits do not come close to the standard required in law to prove justification. And the fact that the update removed this functionality (without any apparent need for new technology to meet a risk) effectively disposes of the point.

EGR DDs

938. The Claimants' case on the broad EGR DDs is as follows. It is not alleged that they are CRDDs, but they are alleged to be DDs.

939. The Claimants say that the defined conditions of the NEDC allowed Mercedes to predict with near certainty other operating conditions within the NEDC: it would reliably know what engine speed and torque combinations ("operating points") a particular vehicle would encounter during the NEDC and how the engine temperature was likely to increase over time. The Claimants contend that Mercedes used this knowledge to calibrate the EGR such that it was less effective off-cycle (i.e. outside these operating points) than it was in the NEDC:

    i) The EGR rate is calculated by first establishing a base EGR rate ("Base EGR Rate"), to which corrections are added. The Base EGR rate is set by reference to current engine speed and Torque. The vehicle checks the current operating point. Each operating point has a corresponding Base EGR rate;

    ii) In general, the Base EGR rate is calibrated to be higher at operating points experienced in the NEDC than those encountered in the NDC outside it ("Base EGR PDD").

940. This is said to be done via a series of EGR Corrections via a process whereby a gross EGR rate correction ("gross correction") is selected from a data map ("Correction Map") and is multiplied by a percentage ("scale factor") from a different data map ("Scale Map"). One correction may have multiple scale factors set by reference to one or more environmental or operating conditions. The scale factor allows a correction to be completely disapplied or reduced in defined environmental and operating conditions. The main corrections said to be PDDs are:

    i) Cooler Mode and Bypass Mode: MBC1 and MBD1 used different EGR Base and EGR Correction Maps for when the CSVs use the EGR cooler or bypass it. Bypass Mode is used and operative in low load, low engine coolant temperatures, low AAT and low atmospheric pressure conditions;

    ii) Base Maps (Toque and Speed): As a result of the calibration of the base maps, the EGR rates in the CSVs were materially reduced at higher engine torques and engine speeds. These are operating points experienced in normal driving but not substantially included the NEDC;

    iii) Air temperature: Thermal windows are said to operate in all CSVs;

iv) Noise correction: Once the relevant threshold engine temperature is reached for the first time outside NEDC, the Noise Correction will be active for the remainder of the drive, and the Scale Factor will not decrease;

v) Engine Start Temperature Correction: If MBC1 started with oil temperature between 20°C-32°C (i.e. in the NEDC Zone), this correction would apply a derate until the oil temperature rose by a few degrees. By contrast, at starting engine oil temperatures of 18°C and below, or 34°C and above, the derate applies throughout until oil temperature reaches 85°C;

vi) Engine Temperature Correction;

vii) Idle Correction: This correction applies when MBC1 is above 80°C engine oil temperature and idles for a second or longer. It applies a substantial 24% derate;

viii) Atmospheric Pressure Correction: each of the CSVs modulate based on atmospheric pressure.

941. Ultimately only a few of these were pursued with any very detailed particularity. Those are considered individually below. The remainder are considered together at the close of this section.

Air temperature modulations/Thermal windows

942. Thermal windows are alleged in relation to MBC1 (original and update), MBD1 (original and update), MBC6 (original) and MBD6 (original).. The windows were:

i) A lower temperature component, namely:

a) below 15°C AAT in Bypass Mode in MBC1 original and below 0°C AAT in MCB1 update;

b) below 10°C AAT in Bypass Mode in MBD1 original and below 5°C CAT in MBD1 update;

c) below 10°C AAT in Bypass Mode in MBD1 original and below 5°C CAT in MBD1 update;

d) below 20°C CAT above 1,800 RPM, and below 10°C CAT at all other engine speeds in Cooler and Bypass Modes MBD6 original.

ii) A higher temperature component, namely:

a) below 20°C CAT above 1,800 RPM, and below 10°C CAT at all other engine speeds in Cooler and Bypass Modes MBD6 original;

b) above 37°C AAT in Cooler and Bypass Modes in MBD1 original and above 50°C CAT in MBD1 update;

c) above 30°C CAT at engine speeds below 1,200 RPM, and at all engine speeds above CAT of 40°C in Cooler and Bypass Modes in MBC6 original;;

d) above 30°C CAT at engine speeds below 1,200 RPM, and at all engine speeds above CAT of 40°C in Cooler and Bypass Modes in MBC6 original;.

iii) The MBC and D6 update had no derate below +50°C CAT.

943. It follows from the conclusions already reached on NDC that the following AAT windows were not PDDs since they only operated outside NDC.

i) MBC1 original (upper limit);

ii) MBC1 update (lower and upper limit);

iii) MBD1 original (upper limit);

iv) MBD update (upper limit).

944. So far as concerns the remaining windows they are at least apt to be considered as PDDs. However it should be noted that the apparent mapping of the apparent mapping of MBC6 and MBD6 original to the NEDC thresholds is not as close as it might appear given that it is CAT not AAT. Given the likely higher temperature of CAT, the windows might be regarded as AAT 10-20°C, and 10-37°C. While the Claimants are right that in MBC6, CAT is measured after the charge air cooler (but before the recirculation of exhaust gas), meaning that the delta between the two would be much less than in other configurations, the different location for measurement and the inevitable delta moves the devices away from any real suggestion of being boundary devices.

945. As for reduction in effectiveness this needs to be considered by reference to the proximity of the derated region to the NEDC test and by reference to the factors which begin to operate before and at the end of the NDC range – such as the need at low temperatures to preserve combustion stability and the fact that increased NOx would be expected at lower temperatures due to increased friction and load. Mr Day's evidence was that based on the Extrapolation Approach the results did not show RIE: "*the majority of the NEDC-based Test results have a CCF of less than 1.0, and that 43 (91%) have a CCF below 2.0. The four tests above 2.0 were all Low Ambient Temperature NEDC Tests*."

946. Mr Day accepted that in the MBC1 IF Low Ambient Temperature Test the AAT Correction had a material impact on NOx in the early part of the test but considered that the material impact on NOx was restricted to the early part of the test. I considered a fairly heated debate resulting from this evidence. Ultimately I have formed the view that the low temperature test forms a less appropriate comparator for RIE given my conclusions on NDC, and that based on the non low temperature tests no RIE is established.

947. So far as upper temperatures go there were no tests in which the higher temperature elements of the correction were triggered, so there is no evidence of RIE.

948. Consequently the Temperature correction/thermal window allegations against Mercedes fail.

Atmospheric Pressure Correction

949. Each of the CSVs modulate EGR based on atmospheric pressure. The issues are not so much as to the existence of the modulations which took place from somewhere around 700m altitude as to (i) the extent to which the boundaries fell outside NDC (ii) the effect in terms of RIE given the lack of test data and the effect of the conditions on RIE and (iii) justification, given the common ground between the experts that at some point it is necessary to reduce the EGR to maintain stable combustion.

950. Mr Smithers' written evidence in chief was that "*[t]he conditions of stable combustion are more limited at high altitude, the conditions which support EGR are also limited at high altitude, and combustion becomes much more sensitive to EGR rate*." But as he said it then becomes necessary to define high altitude.

Application of the modulation

951. This was an area where there was some divergence in the evidence. The Claimants put forward a table which sets out what they say are the Scale Factors for each of the CSVs at different altitude (interpolated to standardise the comparators). Mercedes contended that this actually misstates the position and is "beset with errors" - and certainly the entry of -400% was difficult to follow.

952. It appears that:

    i) For MBC1 and MBD1, the EGR rate was gradually derated once the atmospheric pressure fell below 924.8 mbar (924.8hPa), which occurs at approximately 762m above sea level;

    ii) The MBC6 and MBD6 IF Atmospheric Pressure Corrections reduce the EGR rate below 950mbar;

    iii) The MBC6 and MBD6 UF corrections reduce the EGR rate below 915mbar.

953. All of these fall outside the altitude range of normal driving conditions which has been found above, so the point does not arise. The claim in relation to this alleged PDD therefore fails.

954. Further the bulk of the mechanical engineering evidence across the GLOs tended to accept that these were either at or very close to areas where some adjustment was necessary to maintain stable combustion.

    i) The mechanical engineering experts in the PCD litigation, Professor Martinez-Botas for the PCD Claimants and Mr Richard King for the PCD Defendants, agreed that 930mbar is "significantly below standard atmospheric pressure" and that reduction in EGR rates at this level is "*necessary to preserve combustion stability and engine performance, to avoid excessive soot production, and to prevent driveability issues*";

    ii) The mechanical engineering experts in the Ford litigation, Mr Carder for the Ford Claimants and Professor Millo for the Ford Defendants, agreed that corrections between 900 and 950mbar are acceptable and "*well known in the public literature*".

955. This is one of the areas where Mr Smithers' evidence did not impress. His evidence was out of step with the majority of other experts and his reasons for that divergence were not convincing.

RIE

956. I will however give brief consideration to the RIE evidence. None of the testing conducted in the JTP sought to assess the operation of the ECS at low atmospheric pressures, there is no test data available to assess the impact of these corrections. In the absence of any such data, the Claimants' case that they produce a RIE is based on their "axiomatic principle": that all reductions in EGR lead to a RIE. Mr Smithers similarly asserted that because the EGR rate is lowered, a RIE is caused. The Claimants submit that the JS agreement that "*increased EGR at higher barometric pressures…(c) Engine out NOx likely to decrease*" is determinative.

957. One problem here is similar (but not identical to) the problem of low temperature combustion. Mr Day noted "*[l]ower air density at higher altitudes results in lower oxygen availability and resulting intrinsic combustion differences*".

958. Overall I am not persuaded that given the agreed position as to the need for some adjustment at high altitudes, the fact that the majority of the evidence supported the conclusion that in this respect we were looking at what would normally be called high altitudes, the issues as to the complications caused by atmospheric pressure and crucially the lack of any testing data it is not established on the balance of probability that there was an RIE.

Cooler Mode/Bypass Mode

959. MBC1 and MBD1 used different EGR Base and EGR Correction Maps for when the CSVs use the EGR cooler or bypass it. The different calibrations are referred to as Cooler Mode and Bypass Mode. In MBC6 and MBD6, and following the updates to MBC1 and MBD1, the CSVs used the same EGR maps in Cooler and Bypass Mode. It is agreed that Bypass Mode is used and operative in low load, low engine coolant temperatures, low AAT and low atmospheric pressure conditions.

960. These are alleged DDs which illustrate the extent to which, on its fullest construction the Claimants' case extends to embrace much of the operation of the vehicle simply by reason of the fact that EGR rates are never static.

961. In closing the Claimants advanced no case on RIE and this alleged PDD is not made out.

Base Maps (Torque/engine speeds)

962. As a result of the calibration of the base maps, the EGR rates in the CSVs were materially reduced at higher engine torques and engine speeds. These are operating points experienced in normal driving but not substantially included in the NEDC. Mr Smithers plotted a series of maps that he alleged showed the proportion of time each CSV spent at different operating points on the NEDC and an on-road test. Those were highly contentious and in closing the Claimants do not rely on the maps for quantitative analysis.

963. Mercedes accepted that in general terms it is correct that at lower torques and speeds the Base Map provides for higher EGR rates than at higher torques and speeds, but said that

is not indicative of the presence of a DD. Rather, it reflects the physics of a diesel engine, in which in order to maintain stable combustion it is necessary to modulate the EGR rate at higher torques and higher speeds. Mr Day noted that he would expect different ranges of speed and torque between an NEDC drive and an on-road drive, and therefore different EGR rates, because running excessive EGR in high speed and/or load conditions gives rise to a risk of sub-optimal combustion.

964. The evidence here did not really establish a relationship between the maps and the evidence on torque/speed in the NDC context and thus it was hard even to judge whether any DD existed.

965. However the argument can be short circuited by reference to RIE. The Claimants largely rely on the axiomatic relationship here. However that is negatived by the detailed evidence based on extrapolation. Imperfect as the Extrapolation Approach is, it is the best evidence which is available. It shows:

    i) MBC1: CCFs ranged from 2.28 to 4.18 (excluding the MBC1 IF 20 May on-road test with a CCF of 5.39 which was a test with an abnormal driving style of frequent accelerations which generated higher levels of NOx);

    ii) MBC6: CCFs ranged from 1.03 to 4.48;

    iii) MBD1: CCFs ranged from 0.89 to 2.47;

    iv) MBD6: CCFs ranged from 0.48 to 1.31.

966. The bulk of these test results are therefore giving CFs below the RDE initial CF of 2.1, even before test-to-test variability is taken into account.

Noise correction

967. MBC6 and MBD6 IF employed an ESTG or Noise Correction. The correction modulated the EGR rate by reference to a range of parameters including, amongst others, the engine oil temperature at start, the maximum engine oil temperature during the engine cycle, and the selected gear.

968. Once the relevant threshold engine temperature is reached for the first time, the Noise Correction will be active for the remainder of the drive, and the Scale Factor will not decrease. Engine temperature aside (which is current/dynamic), other key parameters are historic (i.e. the engine oil temperatures at start and the maximum temperature on the drive). The reason why this correction is apt to be a DD is that it is designed not to activate in the NEDC.

969. The only tests where the Noise Correction was not active were the NEDC Tests and the Swirl Deactivation Tests (which are simply NEDC tests with the swirl flap actuators modified). The Noise Correction activated in all the other tests including the Key Off test, the 4 x NEDC tests, the WLTC tests, the RDE tests and the other on-road tests.

970. The Claimants' case is that the Noise Correction was designed to activate only after a first NEDC so that: (i) it would not affect the NOx performance in the regulatory NEDC; but (ii) it would activate on a second and subsequent NEDC carried out back to back. This is said to be significant because Ki factors are calculated by continuously repeating

the NEDC test cycle until a DPF regeneration occurs. The effect was to provide lower NOx in the regulatory NEDC, but (at the cost of higher NOx) to improve MBC6's D number and consequently Ki factors for fuel consumption and on cycle NOx adjustments.

971. So far as RIE is concerned, the Claimants contended that the effect of the Noise Correction was demonstrated in the Key Off NEDC. In this test, the engine was briefly turned off and restarted just before the EUDC (i.e. just before 800 seconds). Other than this, it was a standard NEDC. Tailpipe NOx emissions across the whole NEDC increased by 43% from the Baseline to the Key Off NEDC. These results include the two-thirds of the test prior to the key-off, where MBC6 operated with the same emissions strategy. There was some test-to-test variability in the urban sections of the Baseline and Key Off test (around 8%).

972. The Claimants say that the 258% increase in tailpipe NOx in the EUDC, or 48% increase across the whole test, cannot be explained by test-to-test variability.

973. Mr Day accepted that turning the key on and off in the relevant test impacted engine-out and tailpipe NOx due to the activation of the ESTG Correction. However, Mr Day noted in his report that there are several variables in addition to the reduced EGR rate that may have an impact on NOx emissions so, whilst it was fair to say that the largest correction is the ESTG Correction, it does not follow that the ESTG Correction is responsible for 'doubling' engine-out NOx as asserted by Mr Smithers.

974. The analysis of the data for which Mercedes contended was as follows:

    i) Mr Day calculated a CCF of 1.39 for the MBC6 IF Engine Key Test; he did not consider that this constituted an RIE as the NEDC Engine Key Test is "*made up of two separate drives, the second drive (after the key-off event) being one in which the ECU begins with a warm engine temperature, which gives rise to potentially different risks*";

    ii) The CCFs for all tests in which the MBC6 IF ESTG Correction was active ranged from 0.85 to 4.48 (with the exception of the MBC6 IF Low Ambient Temperature Test (C6i-04), which was conducted at -5ºC and hence outside NDC). Mr Day did consider that there was a RIE in the Low Ambient Temperature test, with a CCF of 7.99, but stated that the ECS was acting as expected to control unstable combustion in cold temperature;

    iii) Each of these tests (bar the Low Ambient Temperature Test and the Claimants' 7th May AM On-road Test (C6i-07)) are below the RDE initial CF of 2.1. Mr Day explained why, in his view, given the conditions on the 7th May AM Test, the CCF of 4.48 did not indicate a RIE. The MBC6 IF RDE test, in which the ESTG Correction was substantially active, in particular had a CCF of 1.64, below the RDE initial CF of 2.1;

    iv) The CCFs for all tests in which the MBD6 IF ESTG Correction was active ranged from 0.83 to 2.49 (with all bar the Low Ambient Temperature Test being below the RDE initial CF of 2.1, and even that test being very close to the RDE initial CF of 2.1 once test-to-test variability is taken into account). Mr Day explained why, in his view, given the different conditions in these tests, these results did not indicate

a RIE. The MBD6 IF RDE test, in which the ESTG Correction was substantially active, in particular had a CCF of 1.29, below the RDE initial CF of 2.1.

975. Despite this, the balance of the evidence seemed to favour the answer that there was some RIE albeit not nearly as great as the initial headline figures contended for by the Claimants. Firstly Mr Day did accept some effect on NOx. Secondly the initial figures are striking. Thirdly the logic of the correction correlates better with some effect (as initially demonstrated) than no real effect. As it was put in closing:

> "If we assume car A and car B are both driving with their engines warmed up with an engine oil temperature of 95 degrees, if car A started at 14 degrees and car B started at 22 degrees, car A's derate will be 25% higher than car B's simply because of the temperature that they started at."

976. Fourthly that effect seemed to be borne out both in the charts in Mr Smithers' report and in the RDE 14/23ºC comparison drawn in closing.

977. I accordingly conclude that this was a PDD.

978. As to justification, the points relied on were broad and generic (soot risk, cold and warm engine temperatures). They were not apt to engage the Article 5(2) criteria.

Engine start temperature correction

979. Although not specifically identified as a CRDD the Claimants' case on this alleged PDD certainly implied that it was thought to be one, with the closing characterising it as "*another egregious example of tailoring to the NEDC*."

980. The allegation in concrete terms is that if MBC1 started with oil temperature between 20°C -32°C (i.e. in the NEDC Zone), this correction would apply a derate until the oil temperature rose by a few degrees. By contrast, at starting engine oil temperatures of 18°C and below or 34°C and above, the derate applies throughout until oil temperature reaches 85°C. As such, at 18°C, the derating/correction will apply until the oil heats by 67°C; but at 20°C it only remains active until the oil heats up by 4°C.

981. There are two short answers to this alleged PDD, which mean that it is not necessary to get into the (justification) arguments about combustion stability.

982. The first is that this is not a differential operation in and out of test: the evidence in Figure 6 of Appendix 2 to Mr Day's report shows that this correction applies for 310 seconds of the NEDC. Thus there is no defeat device.

983. The second is that there is no evidence at all of RIE.

Engine temperature correction

984. This alleged PDD has different manifestations in different CSVs.

    i) In MBC1 original only, this correction applies only above engine temperatures of 80°C;

ii) This correction was changed on update to MBC1: the correction started from 75°C and its extent above 80°C was lowered; and it adopted a warm-up component (up to 30°C engine coolant) and a higher engine temperature component;

iii) In MBC6 and MBD6 as originally calibrated, there are three other components to the correction:

a) An engine warm up component, which applies at engine temperatures up to 40°C in MBC6 and 55°C in MBD6;

b) A low engine speed component (i.e. below 1,000 RPM), when engine temperature exceeds 85°C in MBC6 and 80°C in MBD6.

iv) And a higher engine temperature component, when, at particular engine speeds, coolant temperature exceeds 103°C.

985. This is an example of a PDD not being clearly delineated as what is billed as a single PDD is in reality a bundle of (at least) three alleged PDDs to which different engineering considerations apply: low temperature, Idle (split out as a separate PDD for MBC1) and Higher Temperature.

986. The short answer to this/these PDD(s) is RIE. Applying the Extrapolation approach:

i) MBC1: The CCFs range from 1.06 to 4.18. Further for MBC1 UF, Mr Smithers did not suggest that the low temperature element of the Engine Temperature Correction caused a RIE;

ii) MBC6: The CCFs range from 0.58 to 4.48 (excepting the MBC6 IF Low Ambient Temperature Test (CCF 7.99), which was not at NDC and which Mr Day considered did show a RIE but concluded that the ECS was preventing unstable combustion);

iii) MBD6: The CCFs range from 0.54 to 2.49.

987. On this basis I conclude that RIE is not established.

Idle (MBC1)

988. The Claimants' case on this is that the correction applies when MBC1 is above 80°C engine oil temperature and idles for a second or longer. This is said to be a relatively harmful derate, as it will increase NOx in urban environments, or where the driver is sat waiting. On RIE the Claimants say that as *"it applies a substantial 24% derate, which will plainly increase NOx"*.

989. This is not consistent with the evidence of their expert Mr Smithers which was that the Idle Correction *"had a negligible impact"* on NOx emitted "*during the types of tests undertaken in this litigation*". That evidence was consistent with that of Mr Day who analysed the device over six tests. Again this alleged PDD fails on RIE.

990. Further in relation to the idle correction for MBC6 and MBD6 Mr Day's analysis indicated that an idle state is ideal for the SCR to convert NOx as there is very low NOx mass flow so the SCR can convert NOx at almost full efficiency. Thus in Figure 124 of

RD1 Appendix 5, it is apparent that while there are relatively long periods of idling at 900s and 1400s SCR is at 200ºC with nearly 100% conversion.

SCR devices

991. The Claimants' case on the SCR has three components: (i) the Dosing Release strategy; (ii) the operation of Online Dosing; and (iii) the activation of Online Dosing via the Bits Design. There was also considerable attention directed to the purpose of dual dosing: whether it was there to manage ammonia slip risk or control consumption.

992. This topic is somewhat complex and the nature of the dispute meant that the parties could only give me limited help – as Mr de la Mare said in closing (a submission later adopted by Mercedes):

> "To try to concentrate on all the points in dispute to fine detail in relation to the SCR bit by literal bit, if you will forgive the joke, is obviously impossible and I fear ––and this is easy for me to say and my Lady will certainly think it ––there is no substitute for cold towelling the detail on each bit based on the written submissions."

993. Ultimately (with the assistance of several cold towels) I have concluded that there is something of a way through this, as set out below. However (i) that complexity and the fact that the case proceeded by reference to a plethora of individual Bits and (ii) the issues as to proof of RIE in an SCR system, which will be considered below is another point which in my judgment provides a valuable sense check to the Claimants' case, and illustrates why the CRDD approach is the only workable solution.

994. The broad overview of the case is clear: the Claimants say that there are SCR PDDs in MBC6 and MBD1's original and updated firmware; and in MBD6's original firmware. The case is based on the proposition that there is a direct relationship between the reduced dosing of AdBlue and an increase in tailpipe NOx and that any reduction in the supply of NH3 will result in the SCR converting less NOx than it could have but for the reduction. The Online Dosing PDDs reduce (the Claimants say significantly) the amount of AdBlue the CSVs would have dosed in Fill Level mode in nearly all circumstances. The updates improve the SCRs' performance, but it is still said that PDDs remain in MBC6 and MBD1.

995. In terms of the genesis of the case the Claimants rely on the cartel findings in Commission Decision Case AT.40178 of 8 July 2021: that Mercedes was a participant in a Cartel between mid 2009 and late 2014 that discussed SCR, AdBlue and related technologies in particular regarding AdBlue tank sizes, refill ranges and average consumption. The cartel behaviour does not appear to have resulted in co-ordinated action – the decision records that "*The cars with SCR-systems manufactured and marketed by the parties in the relevant period and in subsequent years did not have uniform AdBlue tank sizes or ranges. The tank sizes and ranges were largely well above the figures discussed by the parties. Furthermore, the technical solutions of the parties for implementing SCR-systems differed.*"

996. However the Claimants say that the documents show that they agreed to devise a system of Dual Dosing to restrict AdBlue consumption and the discussion allowed pretextual justifications to be presented to the authorities if asked. And such justifications were

presented to the EPA in 2015. The Claimants say that whilst the calibrations themselves are complex, particularly as they cumulate, their core objective is discernible and simple: to conserve AdBlue by limiting the supply of AdBlue.

997. The individual PDDs alleged can be summarised as follows:

i) The SCR CSVs switch from Fill Level mode to Online Dosing in defined circumstances. Each circumstance in which Online Dosing can be activated is assigned a "Bit". The Bits are collectively known as a bitmask ("Online Dosing Bitmask"). Bits 1 – 6, 14 and 15 are the most relevant Bits for these proceedings;

ii) For Bits 1 – 6, Online Dosing will activate if the condition defined by the Bit is met for 10 seconds. Once activated, the CSV will remain in Online Dosing until all of the conditions defined by the Bits have been deactivated for a set period.

a) In MBD1 (a 2017 vehicle), the deactivation timer is equal to the activation timer;

b) Online Dosing will only deactivate if the conditions are not fulfilled for 120 seconds in MBC6 and 60 seconds in MBD6, meaning once triggered Online Dosing will work for at least 120 or 60 seconds respectively.

iii) Bit 1 (all CSVs) activates when the temperature of the SCR catalyst exceeds a defined threshold. This can be traced back to the BMW Proposal. This Bit is present in each of the SCR CSVs, and properly parameterised may correspond to the threshold start point for catalysis on the SCR or the high temperatures at which the catalysed reactions tail off. The Claimants say that it is for Mercedes to justify that they calibrated Bit 1 to the appropriate temperature threshold;

iv) Bit 2 (MBC6 IF and MBD6 IF) activates when the mass of exhaust gas flowing from the engine (expressed as kilograms per hour) ("exhaust mass flow") exceeds a set threshold. Bit 3 is similar, but it is for NOx mass flow and is measured in milligrams per hour. These Bits can be traced to Mercedes' August 2006 Common Proposal. These Bits were present in the MBC6 and MBD6 but were removed following a post-Dieselgate update (explored further below). It should not be necessary to rely on Bits 2 or 3 with an adequately designed SCR system with a suitably sized catalyst because the capacity of the catalyst should match the sorts of peak NOx production likely to be encountered in NDC;

v) Bits 4, 5 and 6 (MBC6 IF) activate by reference to engine temperature, ambient pressure and air temperature thresholds respectively. They can be traced back to VW's VE205c proposal. They were calibrated out in post-Dieselgate updates. Mercedes is said to have understood at the time (i.e. from at least 2006) that these parameters were irrelevant to SCR function, but useful for detecting that a vehicle is off-cycle;

vi) Bit 14 (MBC6 IF, MBD1 IF and MBD6 IF) does not appear to be a part of the Bosch common platform, but a Mercedes specific condition. This Bit can only be activated for a defined period of engine runtime from ignition (e.g. 600 seconds). During that period, and subject to other conditions, Bit 14 will activate if the SCR temperature is outside of a defined threshold. The details of this Bit are different in

the CSVs, which are described in the relevant annexes. Mercedes now say the purpose of Bit 14 is to avoid ammonia slip due to: (i) a lack of reaction sites for NOx conversion at lower temperatures and (ii) inaccuracy of the sensors or dosing models. This Bit was removed from the SCR CSVs in updates;

vii) Bit 15 (MBD6 IF and MBD6 IF) becomes operative after the car has driven a set distance (which depends on the vehicle, and is covered in the car specific annexes). Following that trigger distance, Bit 15 activates if the average AdBlue consumption since ignition exceeds a threshold measured in litres per 1,000 kilometres ("l/1,000km"). Online Dosing then remains active until the average AdBlue consumption since ignition reduces below a lower threshold (i.e. there is a skewed downward hysteresis which will over time compensate for shorter journeys in which the Bit has been unable to operate or operate fully). This Bit was present in the OM642 CSVs (i.e. MBC6/D6), but again was removed in post-Dieselgate updates and was not present in MBD1 (released in 2017). This calibration can be traced back to Mercedes' internal August 2006 design. This Bit, for which there are real difficulties in saying that it related to model uncertainty is perhaps the high point of the Claimants' case in this area.

998. The Claimants' written closing on this topic was very long on detail as to the operation of the online dosing bits. At times the case appeared to veer towards suggesting that the Online Dosing approach was in whole or in part a CRDD. However that was not the case which was put. Thus what Mercedes was actually trying to achieve is neither here nor there until one gets to justification, pace Mr de la Mare who placed much emphasis on what could be seen from the contemporaneous cartel documents.

999. The Claimants spent a great deal of time shooting at the target of proving that Mercedes were trying to control consumption, when that to some extent was either common ground or a very safe finding to make on the evidence. Whether or not other factors like correcting model error and avoiding ammonia slip came into it as well, and leaving open the question of which concern dominated, this was plainly a very important part of this design work. As already noted, and as will be seen later, manufacturers leading the charge on SCR were concerned that customers would not or could not be trusted to refill with AdBlue. To the extent that it matters I do substantially accept the submission that Mercedes was trying to deliver range and these bits formed part of that. I accept that this can be seen from the logic and content of the calibrations themselves. While the cartel documents are naturally interesting, the conclusion would follow from the calibration.

1000. There was also a great deal of focus on Mercedes' Article 5(2) case. However that is best considered the far side of reduction in effectiveness, which as noted above presents problems.

RIE

1001. There is (in theory) a considerable battle on the subject of reduction in effectiveness, although the Claimants have not focussed on the topic in such a way as to provide much help in the written closing and chose in oral closing to spend most of the time available for Mercedes SCR on the other issues, including a degree of overkill on the consumption goal.

1002. The Claimants focus on tailpipe NOx. For reasons I have given above, this is not a robust approach to SCR. Mercedes prefer to focus on Absolute NOx (likewise not a robust approach) and the Extrapolation Approach.

1003. The net result is a considerable mismatch, which has been hard to follow. However doing the best I can:

i) The Claimants say that RIE is all very easy: online dosing doses less and therefore RIE: "*online dosing is simply less effective at converting NOx than fill level mode by design*." The Claimants also point to the target efficiency rates in the two modes as speaking for themselves;

ii) Second the Claimants point to a single test MBC6 average conversion efficiency in the EUDC of the fourth NEDC in the 4 x NEDCs was just 38.6% and it passed the NEDC by a whisker with emissions of 78.01 on the average three tests (fail level being 80). On that basis they say only a tiny change in fill level would have made a difference to passing or failing;

iii) Thirdly the Claimants say that Mercedes' case on reduction in effectiveness is tied to an Absolute NOx analysis, and once that is concluded to be wrong, RIE follows;

iv) Mercedes reply (aside from the defence of Absolute NOx) is that the Extrapolation approach also supports their case on RIE, and that the Claimants' own case on RIE is incoherent and fails to discharge the burden of proof upon them.

1004. Overall, I accept the Defendants' submissions (save as to Absolute NOx). In the first place, having put the case on SCR by reference to the Bits, there simply is no joined up attempt to prove an RIE by reference to those Bits. The Claimants' case, save in the one respect of MBC6 steers away from testing results.

1005. Unless therefore the MBC6 evidence can prove the whole case, the Claimants are forced onto an overarching theory approach to RIE. Each of the approaches they espouse to do this is faulty.

i) The inference via dosing (less dosing=more NOx) is faulty. That follows from the nature of the SCR system described above. Dosing and NOx do not follow a direct path. Dosing leads to storage, storage levels vary according to conditions, NOx out depends on the programming of a purge (which can only occur in certain conditions) and its effectiveness. There is simply too much going in an SCR system to draw a line between the two. True it is that there are some words to that effect in some of the disclosed documents. The Claimants particularly like those of Mr Arndt of Mercedes' words in his 2012 presentation "off-cycle emissions are not limited" and to calibration outside the NEDC focusing on "*minimum consumption, minimum particles and max Agility leading to high NOx emissions in off-cycle operation*". However those words are not backed up by data and if expressing logic it remains faulty;

ii) The efficiencies analysis sounds much better at first blush. The Claimants rely on the cartel correspondence saying that Fill Level mode "operated at maximum efficiency" whereas Online Dosing had "lower efficiency" and that the system was designed so that only Fill Level Dosing had "max NOx Conversion (>95%)" but

Online Dosing operated such that "*conversion [percentage is] dependent on raw emission*". However target efficiency is a chimera. Both sides agree that even in the NEDC the SCR system makes available (from storage or dosing) a wide range of dosed amounts of ammonia depending on the predicted or measured amount of NOx presenting to the SCR. There is no single efficiency being targeted: it all depends on the specific conditions at any given point in time. As the Claimants put it in opening:

> "even in the NEDC cycle (which sets the baseline effectiveness of the SCR system as explained above) the SCR system makes available (either from storage or dosing) a wide range of doses of ammonia depending on the predicted or measured amount of NOx presenting to the SCR. The variable dosing is a reflection of the fact that SCR seeks to remove a target percentage, and maintains the level on ammonia on the catalyst, of NOx using either dosed or stored ammonia."

iii) Pursuing this "target" analysis the Claimants' experts wrongly treated the signal SCRMod_etaEst as representing the rate of NOx conversion that the system was targeting when in FL Mode, when it fact FL targets a certain level of storage rather than conversion and the signal represented the modelled estimate of the conversion rate that the system was actually achieving in both modes ("ACR"). He also treated the signal SCRFFC_etaPreCtlMode2 as representing the rate of NOx conversion that the system was targeting when in Online Dosing Mode (i.e. the "TCR"), when in fact it represented the dosing scaling factor that is used to determine the dosed amount in Online Mode (the "Online Dosing Factor"). Mr Smithers working on this basis thereby went down a blind alley in attempting to estimate target efficiency of Online Dosing Mode without taking into account the (important) contribution of stored ammonia.

1006. One therefore has to come back to the test data. On this:

i) Bit 1 did not trigger at all in the JTP for MBC6 IF. Mr Smithers noted this and did not opine that Bit 1 caused a RIE in the IF for MBC6. Given this, the Claimants have not proved that Bit 1 causes a RIE in the MBC6 IF;

ii) MBC6 UF: Mr Smithers' analysis was not actually relied on by the Claimants in closing. To the extent reliance was still placed on his evidence, he analysed three Bit 1 events in the JTP for MBC6 UF, but only considered one of these to result in a RIE: the Bit 1 event in the Claimants' PEMS test (C6u-20). However, overall the analysis shows an improvement in SCR efficiency with calculated actual efficiency increasing from 73.1% in the "Before FF Event" to 84.5% in the "Entire FF Event". The CF for the entire test is 2.16. Mr Smithers' case that it did show RIE relies on his "julienning" approach. Mr Smithers also concluded that there was a RIE during Online Dosing on the basis that tailpipe NOx was reduced to 68 mg/km is in FL Mode in the RDE test; but this test was one of the "aggressive" driving tests – resulting in an "apples and oranges" comparison;

iii) For MBD1, Bit 1 was only triggered during Claimant Test 3 (D1i-08), which Mr Smithers analysed. Again, the calculated actual efficiency improved during the Bit 1 events analysed. The data therefore does not support the Claimants' case that there is a RIE. Nor does Mr Smithers: he concluded that the activation of Bit 1 does

not necessarily result in a RIE. The Claimants relied on Figure 11-28 of Smithers 1 as demonstrating that Bit 1 results in a reduced ammonia load, and as such "*it is likely that the FL dosing events that follow the first and second bit 1 events would have had lower tailpipe emissions had the online dosing events not take place*". That is a false assumption: the ammonia load setpoint reduces during both of the Bit 1 events, which means that dosing would have reduced even if the SCR had remained in FL Mode;

iv) Bit 1 in the MBD1 UF: Bit 1 was only triggered on the Claimants' hot PEMS test (D1u-18). Mr Smithers tentatively asserted that Bit 1 "*does seem to result in reduced effectiveness, though again it is hard to make a universal statement given the limited data and the conflicting data …*". In fact taking out of the equation the overly dynamic driving it produces a calculated actual efficiency of 70%, virtually identical to the 69.1% during the Bit 1 Event, demonstrating that there is no RIE;

1007. As for Bit 2:

i) Bit 2 was triggered twice in the RDE test (C6i-09) for MBC6 IF; only one of which Mr Smithers considered led to a RIE. However tailpipe NOx during the Bit 2 events was 2.1 times the Emissions Limits, which not only complies with the initial RDE CF, but ignores that the CF for the entire test (which is what matters) was even lower at 1.64. The fact that the UF achieved a higher SCR efficiency for the same exhaust flow rate is neither here nor there given software differences;

ii) Bit 2 did not trigger at all in the JTP for MBD6 IF.

1008. Bits 3-6:

i) Bit 3 was only active in combination with other bits during the motorway portion of Cs' PEMS test (C6i-07). If it cannot be isolated no RIE can be proved;

ii) Bit 3 was triggered once in the MBD6 IF testing and Mr Smithers noted that "*emissions are below the standard for the bit 3 period*": in other words no RIE was suggested;

iii) Bit 4 did not trigger at all in the JTP for MBC6 IF;

iv) Bit 5 did not trigger at all in the JTP for MBC6 IF;

v) Bit 6 in the MBC6 IF triggered Online Dosing once during the JTP, in the cold ambient test (C6i-04). Mr Smithers concluded this was a RIE because (i) tailpipe NOx was 4.6 times the standard during the Bit 6 event; and (ii) the performance of the UF was "much improved" in the absence of Bit 6. However this was a test where much higher NOx levels were being created: (1326 mg/km, compared to 173 mg/km in the Baseline NEDC (C6i-01), and 485.7 mg/km in the UF cold ambient test (C6u-22)). The efficiency was in fact very close: 54% plays 56%. Therefore no RIE is proved.

1009. Bit 14:

i) Bit 14 did not cause a RIE in the MBC6 IF. It only activated for a short period and Mr Smithers correctly noted that its activation did not lead to a RIE in some cases. The Claimants' arguments in closing were theoretical and speculative;

ii) Bit 14 did not cause a RIE in the MBD1 IF: Mr Smithers analysed several Bit 14 events in the MBD1 JTP and did not find a RIE;

iii) Bit 14 did not cause a RIE in the MBD6 IF. Mr Smithers analysed two Bit 14 events in the MBD6 IF JTP, in relation to which he concluded that "*there is no significant depletion of the ammonia load and efficiency remains high in the test conditions explored*" and acknowledged that "*because bit 14 events have a fundamental time limit the impact on overall emissions is likely to be small*".

1010. Bit 15:

i) Bit 15 in the MBC6 IF triggered Online Dosing twice during the JTP, in the 4x NEDC test (C6i-12) and the Claimants' PEMS test (C6i-07). As to the 4x NEDC, Mr Smithers thought it "remarkable" that, during the Bit 15 event, tailpipe NOx was 3x that in the Baseline NEDC test and he relied on the increased CF (4.1 in the urban phase and 2.6 in the motorway segment) in the PEMS test and concluded as a result that Bit 15 "*clearly results in a significant reduction in emission control system effectiveness*". However Mr Smithers again was not performing a like for like comparison: in both tests, the SCR was contending with much higher engine-out NOx. (The levels in question were 514.41 mg/km in the 3rd NEDC and 501.6 mg/km in the 4th NEDC as compared with just 173 mg/km in the Baseline NEDC and 806.6 mg/km as compared to 173 mg/km (i.e. 4.66 times higher)). It follows that the SCR was converting far more NOx. On the evidence it was in fact working at an identical or improved efficiency as compared with the Baseline NEDC test. Further, the stabilised conversion efficiency of around 64% during the Bit 15 event, demonstrates higher conversion than NEDC;

ii) Mr Smithers stated that Bit 15 did not trigger at all in the JTP for MBD6 IF and therefore, that "*the impacts could not be quantified*". It follows that there was no RIE.

1011. Accordingly, when one drills down into the data using the best approach possible, the evidence is that there is no RIE. The Claimants' desktop analysis cannot be said to outweigh this evidence. Largely it depends upon oversimplification as was apparent not just from the test results, but the hedges to the case which appeared in oral argument. For example in reply Mr de la Mare accepted:

> "The reduction in the SCR's conversionability may be modest in some circumstances or at least modest initially if the storage level in the catalyst drops only slightly. That is going to be a function of when online dosing is triggered and whether the car had a full catalyst and whether, after online dosing being triggered, the conditions are ones in which low amounts of engine−out NOx are produced so that catalyst depletion happens slowly."

1012. This illustrates some of the range of variables which feed into the SCR operation. Desktop analysis may be temptingly clear, but it is against this backdrop speciously clear.

That is doubtless one reason why testing was sought and pursued with such vigour. The testing has not demonstrated the case.

Justification

1013. In the circumstances justification does not arise and will not be considered at length. However the following comments may be useful:

i) The evidence provides some basis for all of the invoked issues (consumption, ammonia slip, modelling errors) being considered in the context of calibration. However consumption appears to have been the most active concern;

ii) Ammonia slip was a valid concern, as Mr Smithers accepted ("*the risks of ammonia slip can arise when the SCR catalyst temperature is high and the SCR catalyst has a high ammonia load*"). Further:

a) In MBC6 IF and UF, Ammonia Slip in fact occurred during the JTP and it did so at 280°C;

b) While developing the calibrations for the UF, Ammonia Slip of over 100 ppm was detected at 260°C, which was mitigated but not eliminated through the switch to Online Dosing.

iii) To the extent that ammonia slip was a concern there is some evidence of calibration being performed to accommodate this as well as consumption concerns: thus Bit 1 in all the MCSVs falls within the range of temperatures at which there is at least some risk of Ammonia Slip;

iv) Whether this concern justified the DD if there was a DD is in my judgment dubious on the evidence. See above regarding the need for assessment of the severity of the risk.

THE FORD CSVS

Introduction

1014. The Ford Group is an umbrella term for a group of companies, of which the Ford Motor Company is the ultimate parent company, headquartered in Michigan, USA.

1015. There are six Ford CSVs, as follows:

CSV	Engine		ECS technologies
FC1 Focus (2013) Euro 5b	DLD-416 (DV6)		HP EGR, cDPF & DOC
FC5 Transit (2014) Euro 5b	Puma		HP EGR, DPF & DOC
FD3 Fiesta (2014) Euro 5b	DLD-415 (DV5)		HP EGR, cDPF & DOC
FC6 C-Max (2016) Euro 6b	DLD-415 (DV5)		HP EGR, cDPF, LNT & passive SCR
FD5 Mondeo (2017) Euro 6b	DW10F		HP EGR, cDPF, LNT & passive SCR

CSV	Engine		ECS technologies
FD1 Transit (2018) Euro 6b	Panther-EcoBlue		HP EGR, sDPF, DOC & active SCR

1016. On the Ford CSVs the Claimants' case is that (i) Ford deliberately optimised the ECS to the NEDC test; (ii) Ford was able subsequently to re-calibrate its ECS without any changes to the vehicle hardware; and (iii) such recalibration (and its speed) is fatal to any argument that the original calibration was justified. In relation to the Ford case, factual evidence was called.

1017. The Ford factual witness was Dr Marcus Davies. He was, at relevant times, Manager of the Core Diesel Calibration team developing common global processes for Diesel calibration. The Claimants contended that it was significant that Ford did not call any witness who was involved in the original design or calibration of the Euro 5 vehicles or initial discussions about re-designing and re-calibrating its ECS for the Euro 6b standards. They submitted that the evidence of Dr Davies was of little value to the Ford case given, he had no direct involvement in the diesel calibration team until 2015[1] and cannot therefore speak directly to the motivation of those who directed, designed and implemented the original calibrations.

1018. Dr Davies was an obviously diligent and thoughtful man, who came from an environment where a responsible attitude was frequently voiced as to safety and defeat devices (see the Ford mandatory defeat device avoidance training slide decks). This perhaps coloured his answers which sometimes erred on the cautious person's side of being realistic – for example in his refusal to accept the proposition put to him by Mr Jaffey KC (early on in his evidence) that speeding is common.

1019. At the same time there was no doubting the genuineness of his answers in cross examination as to the necessity of focus on the balance of emissions control. So for example:

> "A. No. What I'm trying to articulate is the fact that if you take NOx, for example, that on-cycle or as your NOx changes, so does the other regulated gases and the calibration process and the overall calibration philosophy is to have an effectiveness of control across all of the regulated gases and this is saying that what we shouldn't be doing really is just doing a focused effort on one gas, it's really looking to ensure that you have effect effective control across all of the gases that are regulated"

Torque/Speed

1020. Ford calibrated its vehicles to modulate the EGR rate in response to a combination of engine torque (measured in Nm) and engine speed (rpm). The EGR torque and engine speed calibrations are agreed between the parties. The dispute between the parties is

whether that modulation amounts to a DD and/or was justified. The Claimants seek a ruling that:

i) As part of its EGR Strategy, Ford utilised an Engine Parameter Defeat Device - the "Torque/Speed EGR Device" pursuant to Art 3(10) ER; and

ii) The Engine Parameter Defeat Device was not justified, pursuant to Art 5(2) ER and amounted to a PDD.

1021. The way in which the calibration operated in this respect was agreed between Dr Heitz and Mr Migliorero:

i) The ECU in each of the CSVs controls the EGR rate through the operation of Base Maps. The number of available Base Maps varies depending on the specific CSV. Each CSV modulates EGR by reference to engine speed and torque. The relevant Base Map (0-5) is selected as a function of coolant temperature and intake air temperature;

ii) Within each Base Map, EGR rate is modulated as a function of speed and torque. In some CSVs (FC6 and FD3) the ECU modulates EGR rate directly. In other CSVs (FD1, FC5, FC1 and FD5) the vehicle modulates MAFSP, which then has a necessary impact on the amount of EGR run. In general terms, the higher the index number attributed to a particular Base Map number, the warmer the thermal state of the combustion engine and intake air (except for FC5 in which the inverse is correct);

iii) Once a Base Map is selected, a desired EGR rate setpoint or MAFSP (depending on the particular CSV, as set out in the CSV Table above) is determined by engine torque and engine speed. Intermediate points in the maps are interpolated. The desired setpoint may then be adjusted by corrections, for example for IAT and ambient pressure;

iv) Which Base Map is selected depends on several factors. During the warm-up phase, the ECU interpolates continuously between the Base Maps based on ECT and IAT. When the engine is in a hot state, the ECU switches discontinuously between two Base Maps, based on vehicle speed and gear. The Base Map activated at the higher speed is referred to as the "hot fast" map, while the other is referred to as the "hot slow" map;

v) The Base Maps operate the same in the NEDC and on the road.

1022. The nature of the Claimants' case in respect of this alleged PDD developed somewhat during trial. Initially the case was effectively that any modulation of EGR at higher speed/torque was impermissible. But that argument was plainly doomed to failure, as Mr Carder's omission of it from his report indicated. Modulation at higher speed and torque is to some extent inevitable – to put it brutally: the last thing you want is your engine stopping at 90mph or when accelerating to avoid a road hazard because there is too much EGR.

1023. As torque and engine speed increase, the engine requires more fresh air to provide the oxygen which oxidises the additional fuel injected to meet the power demand. That

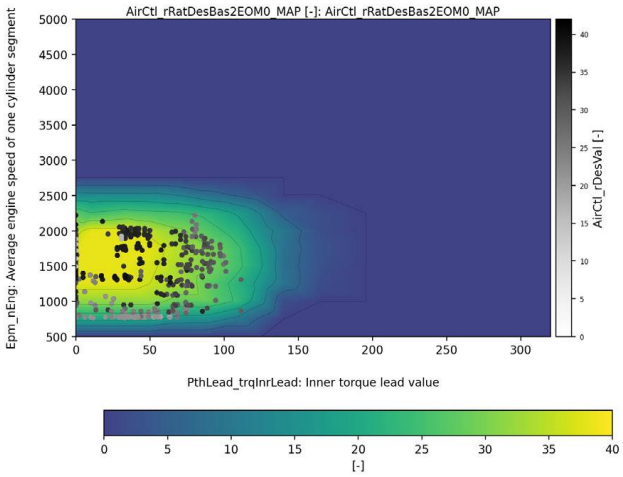
therefore leaves less room for EGR. The mechanical engineering experts agreed in the Mechanical Engineering Joint Statement that EGR must in consequence be modulated with reference to torque. The mechanical engineers agreed that "*modulation of EGR is necessary to control emissions due to changing engine and environmental conditions and can be based on engine speed, engine torque, engine coolant temperature, intake air temperature, and ambient air pressure*."

1024. From here it follows that the calibration for speed and torque involves judgment and there is no one absolutely right answer. The Claimants also did not pursue the pleaded points in relation to individual settings, for example as to the effect of EGR modulation above 110Nm in Base Map 1. There was no testing geared to these allegations.

1025. The Claimants' case as developed focussed more on three strands – optimising to the NEDC test, axiomatic correlation between EGR and NOx leading to a case that, while there was no switch, the EGR worked better in test than out, thereby amounting to a PDD and contemporaneous documents.

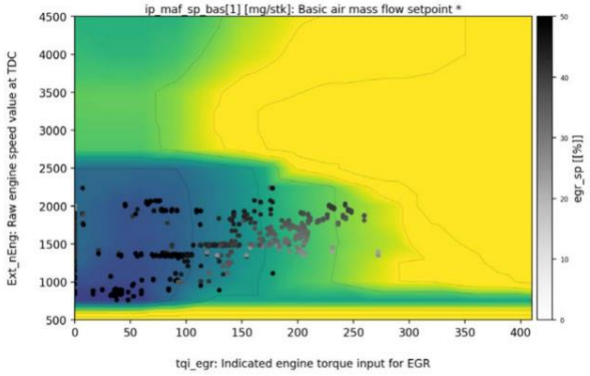
1026. The calibration to the NEDC test allegations occasionally flirted with being an allegation of a Boundary CRDD, but that case was never squarely advanced and Mr Carder gave clear evidence that he did not see this as a switch device. Further I accept the submission that Dr Heitz's scatter plots and Base Maps on which the Claimants relied, on closer inspection tended to disprove such an allegation – while the NEDC nested within the high EGR range, so too did considerable areas of non-NEDC conditions. See the examples below:

i) For FC6 in warm up EGR can be seen to run to 150Nm and 2500rpm whereas the NEDC runs only between 100Nm and 2000 rpm (blue indicates low EGR rate and yellow the maximum EGR rate):



ii) Similarly for Hot Slow phase in FC5 there is dark green MAFSP up to c.2600rpm, whereas the engine residency on NEDC is broadly below 2000rpm. Dark green MAFSP continues up to c.300Nm, but the engine residency on NEDC is generally below 200Nm with some limited residency at between 200Nm and 250Nm (the diagram plots NEDC residency within each Base Map over a background which represents MAFSP or EGR rate depending on the vehicle). As expected low MAFSPs, indicated in yellow, generally appear at high torques and engine speeds because (fairly obviously) at high loads more fresh air is required to combust the

injected fuel to meet the power demand of the vehicle. Of course there is high EGR demonstrated within the test – but that is not surprising, given that the NEDC test is a relatively low load test:

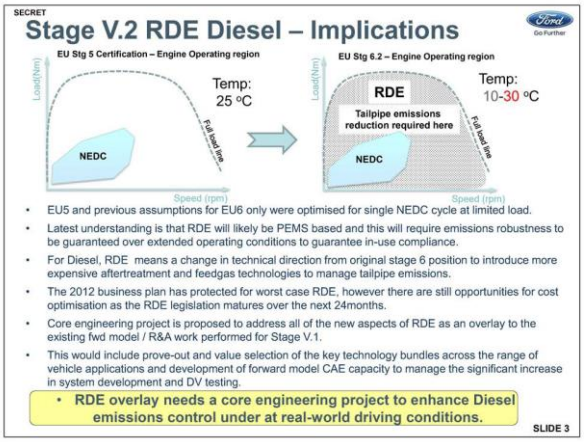


1027. That evidence was supported by Professor Millo's plots of engine operating points on an on road test, which showed the overwhelming majority of the engine operating points were within torques and engine speeds covered by the EGR Base Maps with only a few isolated points, where (predictably) the engine experiences high torque low engine speed and where the EGR percentage decreases to zero. This supports a case that the Ford calibrations coincide with real world driving, not simply NEDC.

1028. The essence of the point was really that Ford did calibrate to the test, that Ford could have calibrated less conservatively and that by calibrating broadly to the test there was at least a tacit decision not to operate the same or similar EGR rates in some (but not all) NDC. A theme of quite a lot of Mr Carder's interesting and thoughtful evidence was geared to this sort of question: is it really enough to calibrate to pass the test, and not to think quite hard about how much further outside the test one could operate with similar results? Overall Mr Carder (a noted Ford enthusiast) was disappointed with Ford's failure to consider this proactively and supported the Claimants' case that the "conservative" Ford calibration approach amounted to a PDD.

1029. This was contextualised by (i) his experience of PEMS having been used rather earlier in the USA than it was in the UK (ii) what he saw as disappointingly high results for NOx emissions in NDC and (iii) Ford's success in bringing a much wider range of conditions within the NEDC limits via the 6.1M update by the time that Euro 6 was coming into effect.

1030. As to calibration to the test, it was established and more or less accepted on the evidence that for its Euro 5 vehicles, Ford calibrated the EGR rate to meet the specific demands of the NEDC test. Ford calibrated with the test as a starting point, if not actually absolutely to the test. That was illustrated by this slide from a pre-RDE planning session in 2012:



1031. At the same time it is fair to say that Ford was not focussed solely on this but on achieving an engine map that would definitely pass the NEDC, but balanced NOx, CO_2 and other pollutants across the entire engine map.

1032. Given that approach and in the light of the way in which the claim was (and was not) pleaded and advanced it is best to focus on the case on reduction in effectiveness, which was there in the originally pleaded case and at least in the written opening argument. In written closing the Claimants did not directly engage with this at all.

1033. Here the evidence (and absence of evidence) reinforces the points made above about the difficulties of the broader PDD case. The questions which present themselves are considerable:

i) Given that increased speed and torque will make greater demands on the engine, maintaining the same EGR may lead to less effective NOx reduction; although there will come a point where, as Professor Millo said, the load in the recirculated gas will start to operate more effectively than it does at low load. How can one say at which point which mechanism is in operation?

ii) Given the increased load and speed and dangers associated with it some increased NOx may be regarded as permissible – what is the wrong side of the line in terms of increase?

1034. These are not questions to which the Claimants offered answers, and Mr Carder expressed sympathy with the Court's task in attempting to draw such lines.

1035. At the end of the day the evidence does not permit me to say how much more EGR should be run by Ford at which torques and engine speeds. It might however be possible to say that the results indicate that wherever in a range the line should be drawn Ford's results demonstrate that they are the wrong side of the line.

1036. Here the Claimants rely heavily on the same limited number of charts. In the first place they rely again on the scatter plots from Dr Heitz's report showing in impressionistic terms a very good alignment between the NEDC test and the results – for example with higher EGR rates for FC6 concentrated below an engine torque of 150Nm. This however goes really to the unexpressed boundary device case considered above. It can only assist on RIE if one accepts that there is a linear or axiomatic relationship between EGR

reduction and RIE. As noted earlier in the judgment this is not a sufficiently safe inference to establish a case.

1037. Secondly the Claimants rely on adaptations of Professor Millo's frequency charts which show that there are numerous engine operating points outside of the frequency points and which fall into areas where EGR operates little or not at all. Then the Claimants rely on a 2015 Ford presentation showing that in RDE testing short periods in high torque are spike points for NOx emissions, and which were targeted and brought within limits for compliance with the RDE test.

1038. The difficulty here is that this takes us back to the questions above and what would be expected – high speed or torque are factors which may justify a calibration adjustment. The existence of internal documents such as this or the 2015 RDE Dunton test simply re-pose and do not answer the question.

1039. The way in which the question was supposed to be answered was via the JTP. This is one of the areas where the results are not adopted by the Claimants with any degree of enthusiasm. The Defendants have naturally made criticisms of the robustness of the results in the light of lack of scope for repetition of tests, the ages of the vehicles and the lack of clarity as to whether they are really operating as they should be; as well as inter-laboratory variability and lack of data collection for some tests. As will already be apparent they also raise issues with the absence of any testing by the Claimants with a view to a number of the issues ultimately pursued, as well as some of the pleaded case.

1040. The results of that testing show (as one might expect) a divergence from the NEDC limits.

1041. So far as concerns NEDC+10% which the Defendants convincingly say appears to be the closest proxy for a simple raise in torque and speed seems not to demonstrate any appreciable increase in NOx. The NEDC +10% test for FC6 produced only a 2-3% increase in emissions when compared to the baseline NEDC. Professor Millo considered that a 10% increase in vehicle speed results in approximately a 21% increase in engine torque, 17% in the EUDC portion. While Mr Carder suggested that the increase was actually 5.7% his methodology appeared to be less rigorous, being based on a 23 second window only and based on estimates from the ECU rather than actuals from the dynamometer.

1042. However whichever torque figure is correct, the uplift in NOx appears to be small – perhaps reflecting the extent to which non-NEDC conditions are in fact covered by the EGR maps as noted above. Similar results were produced for all tested vehicles. The results of this test are not indicative of an RIE.

1043. The Claimants, to the extent they relied on the JTP testing pointed rather to the on road testing. Their headline point was that every CSV exceeded the relevant regulatory limit when tested on the road, some by very large margins: for example, FC6 (pre-update) had CFs of between 5.69-9.98 times the regulatory limit; and increases of between 3.11-5.45 times the Baseline NEDC. These are amongst the very worst performing vehicles across all manufacturers tested. NOx emissions uniformly increased in the on-road tests as opposed to the Baseline NEDC Test (as much as 4.20–7.44 times the Baseline NEDC result, in FD3's case); and exceeded the relevant regulatory limits (with CFs of 2.50-4.53, in FC5's case).

1044. On road testing provides a troublesome comparator given the very different nature of the exercise; it is well understood that a 1:1 ratio could not sensibly be applied. But in this testing the problem is amplified by the fact that on road testing was done on a variety of routes in a range of traffic conditions and with a range of driving styles.

1045. Then there are the problems caused by the fact that it is impossible to look at the on-road testing results and identify that an increase in NOx at a certain point is caused by the vehicle operating an EGR rate for a given torque and engine speed of 15% rather than 20%. The data set also does not identify the injection timing, injection pressure, and boost pressure at any given point in the test data. The mechanical engineering experts agree that each can affect NOx emissions.

1046. The result is that if one poses the question in relation to an on-road test whether a spike in NOx in a certain condition is caused by any of, or some combination of: EGR rate changing; increased vehicle load; injection timing; injection pressure; or boost pressure, there is no way of answering that question.

1047. Further, no NOx sensor was installed after the engine to measure engine out emissions. So, in systems equipped with aftertreatment, the Court cannot even identify what increase in emissions is caused by a change in EGR, as opposed to LNT or SCR.

1048. So the NEDC +10% dynamometer test (designed to test increased torque and engine speed) would be expected to produce increased NOx, did produce increased NOx but not to the extent which would provide a clear answer.

i) For FC6

a) NEDC +10% test produced only a 2-3% increase in emissions when compared to the baseline NEDC. Given an approximate 17% increase in engine torque (Professor Millo's figure after a dispute with Mr Carder was taken into account, produced by a more robust method than Mr Carder's analysis which produced 5.7%) and 10% increase in fuel rate this might be said to be less NOx increase than would be expected;

b) EGR continued to operate, suggesting a negative answer to the boundary device argument;

ii) For FC1 the NEDC +10% speed tests (CD2) produced on FC1 38% higher NOx emissions against what Professor Millo assessed as a 33% increase in fuel rate, the increase is larger but still close.

1049. Against this background I agree that it is hard to draw conclusions from the on road testing. I further accept the submission that Mr Carder's suggestion of a CF of 2 for the on road testing was not a realistic reflection of the question before the Court and was more a reflection of his feeling that Ford could have done better. His CF was less generous than the CF of 2.1 adopted for the RDE test, thereby holding the CSVs (which had no legislative on road target to meet) to a higher standard (2 vs 2.1) than the first wave of vehicles subject to an on-road standard. Any CF used in this context would have to be one geared to:

i) Falling outside the range of judgement at the earlier stage in the emissions control regulation's history;

ii) Taking into account the conceptual difference between the RDE and this "at large" on road testing;

iii) Taking into account the difficulties and anomalies produced by this testing cohort and testing regime.

1050. No such case was offered. Had I to reach a conclusion I would say that the CFs of between about 4 and 8 for the on road testing (similar to those shown in a Ford "Lunch and Learn" Presentation) are concerning but not sufficient to form a basis for saying that there was on the balance of probabilities a reduction in effectiveness.

1051. There is then a question about whether contemporaneous (or near contemporaneous) documents shift the dial on this. The Claimants relied on:

i) Ford's internal documentation in February 2016 which recorded that its vehicles performed consistently worse than its competitors in terms of levels of NOx emissions in testing conducted by regulatory authorities, noting that Ford's vehicles were in the worst 20% of vehicles tested in UK and Germany;

ii) The results of testing conducted by the DfT, which showed significantly higher levels of NOx emissions when a NEDC test was run on a track, instead of on a chassis dynamometer. Ford determined that the DfT results, which recorded levels of NOx emissions exceeding the regulatory limit by up to 12 times for a Stage 6.1 vehicle, were in line with their expectations, concluding that *"NOx emissions higher due to the high engine load as well as unknown pre-conditioning;*

iii) In a presentation authored by Dr Davies (among others) in October 2012, Dr Davies and his colleagues were already recommending extending the operation of the EGR, LNT and SCR across a wider range of operating conditions. Dr Davies acknowledged that these recommendations were aimed at improving real world emissions of NOx and when introduced they did reduce emissions by about half.

1052. On the 6.1M update, on which the Claimants relied as showing that there was a PDD at Euro 5 level, because no hardware changes were necessary, this represents a misuse of hindsight. The fact that Ford was able at a later stage, with a good 18 months to 2 years extra of development time on the part of a team of 15-20 people and a test fleet of 20 vehicles to produce a calibration which increases the range of EGR operation does not mean that this could have been done at the time of Euro 5 planning, design and calibration. Dr Davies explained the timeline of Ford development for Euro 5 and Euro 6 and how the setting of RDE limits prompted the development which led to this calibration. The Claimants' reliance on a single slide dealing with a single PEMS unit in a single research facility was not sufficient to displace this evidence. Nor was the 6.1M update capable of cross-deployment to all engines.

1053. Finally some mention should be made of the exchanges with regulators on which both sides relied, Ford to say that the regulators had no problem with their approach and the Claimants to say that Ford had "spun" the results. I do not consider that these assist much in either direction. The Claimants are right to a limited extent. The communications were

not a warts and all presentation, but a best foot forward one. Reading between the lines one might well infer a degree of sensitivity/concern on Ford's part and an unwillingness to buy trouble. But I reject the allegation of misleading.

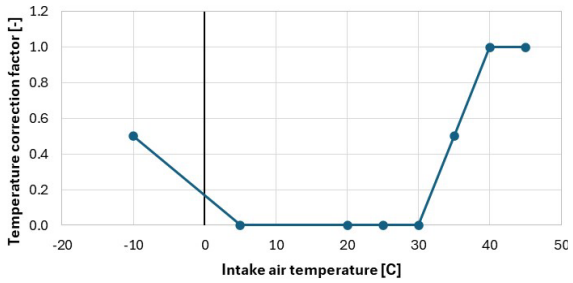
Temperature

1054. There is no dispute regarding FD5. It is not in dispute that Ford calibrated its other vehicles to modulate the EGR rate in response to IAT. The dispute between the parties is whether that modulation amounts to a DD and/or was justified. This was not alleged to be a CRDD or boundary device.

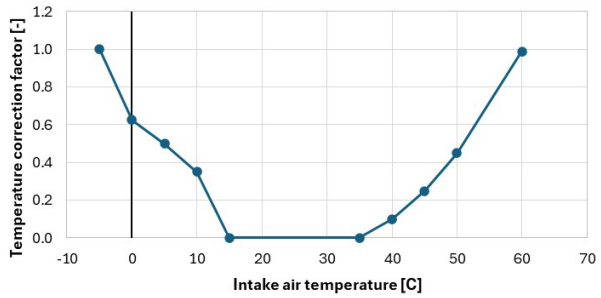
1055. Ford vehicles apply correction factors to EGR rate or MAFSP (depending on the CSV) in a staged way as intake air temperature changes, until the maximum correction is reached. This ramp down of EGR occurs at both high and low temperatures. The Claimants' case focusses on the temperature at which the derating commences, alleging that it is impermissible to derate at any temperature above/below, the identified starting point.

1056. The operation of the temperature correction factors for each CSV is graphically represented in the below figures (extracted from Professor Millo's report). These show that:

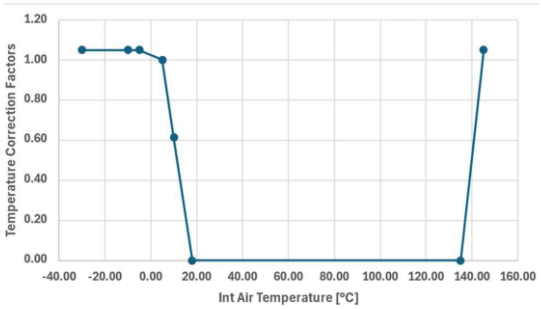
i) FC1's EGR rate was reduced from below 5ºC IAT and from above 30ºC IAT;



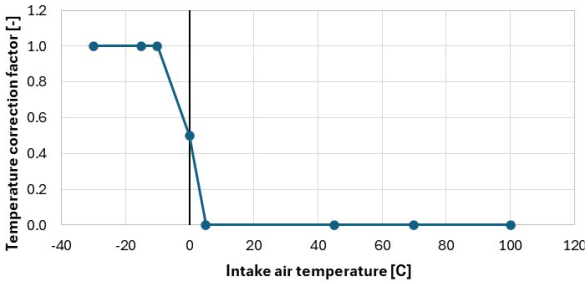
ii) FC5's EGR rate was reduced from below 15°C IAT and from above 35°C IAT;



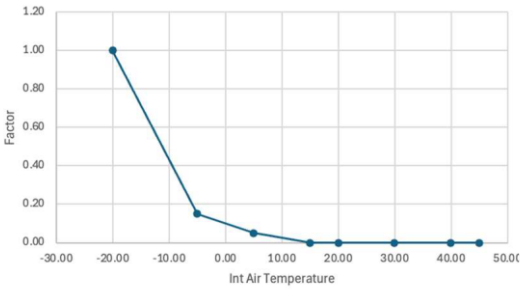
iii) FD3's EGR rate was reduced from below 17.96°C IAT;

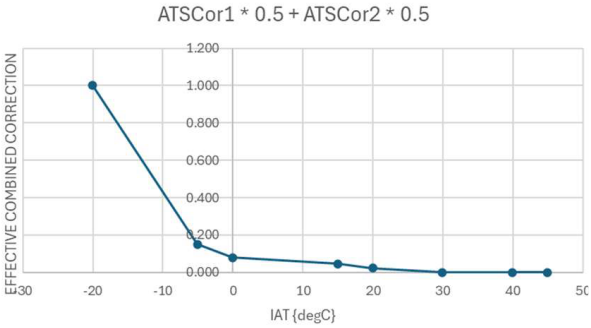


iv) FC6's EGR rate was reduced from below 4.96ºC IAT;



1057. FD1's EGR rate was reduced (i) from below 14.96°C IAT with more significant reductions below 5°C IAT for the base firmware (left plot); and (ii) below 19.96°C IAT, with more significant reductions below 10°C IAT for the updated firmware (right plot):





1058. The real centre of the allegation relates to FD3 and to a lesser extent FC1 and FC5.

1059. A case was technically pursued in relation to FD1 (original and update) but, given the parameters involved and my findings on NDC, that case must fail.

1060. Similarly in FC6, there was no decrease in the EGR rate at all at temperatures below 4.96°C, in all base maps (e.g. "*For Base Map 2, the EGR rate decreased from around 31% at 5°C to 17% at 0°C, for an engine torque at around 70 Nm*") and full derating did not occur until -10°C. While the Claimants allege that 5°C is a condition which may reasonably be expected to be encountered in normal vehicle operation and use (i) that ignores that it is IAT (rule of thumb 5°C higher than AAT) and even without that (ii) it

is only marginally above the lower edge of the NDC window. The result is that even before considering the testing, the Claimants' submission that any modulation below that temperature "*significantly reduced the effectiveness of the ECS in conditions which could reasonably be expected to be encountered in normal vehicle operation and use*" and is a DD must attract a degree of scepticism. In addition, it was not supported by Mr Carder in his evidence.

1061. As for FD3, this was in some ways one of the most striking temperature results, and came closest to the concept of a boundary device (a fact which the Claimants suggested was not unrelated to Ford's lessened enthusiasm for that concept). However again the window was an IAT not AAT temperature so the correlation is (on a rule of thumb basis) somewhat less; and this particular intake sensor was at a sensor post turbocharger not preceded by a charge air cooler, with the result that it would be higher than other IAT temperatures. Professor Millo estimated the differential to AAT as at least 7°C rising to up to 90°C in the EUDC portion of the test. Mr Carder accepted at 10-100°C differential. Accordingly, the AAT equivalent of this temperature will be far closer to the NDC limit than this figure suggests.

1062. This is reflected in the expert agreement that "*The temperature ranges listed are reasonable, well known in the public literature, and acceptable to use as a basis to modulate the ECS on temperature*."

1063. There may therefore be (marginally) a DD (subject to RIE) for FD3 compared to the NDC limits, but the evidence reveals why the Claimants did not overtly pursue this as a boundary device.

1064. As for FC1 the fact that the temperature being measured was IAT and the close proximity to the limit I have found of NDC means that I would not conclude that there was a DD. For FC5, despite the fact that it is not a switch device but a ramp down and the derate is geared to IAT, the calibrations would amount to a defeat device, subject to the question of RIE. However these factors would suggest that any RIE would be marginal.

1065. When it comes to RIE the evidence did not establish any RIE. Mr Carder's evidence did not deal with the effect of the calibrations on engine out NOx. On this he effectively produced a nil return::

i) Mr Carder conceded that: "*Without a more comprehensive testing program, it is therefore not possible for me to give an opinion on whether the calibrations have been set appropriately in respect of these Sample Vehicles*";

ii) In the context of FC6 Mr Carder accepted that:

a) It is impossible to disaggregate from the available test data to what degree any change in NOx might be caused by (i) the inherent physico-chemical requirements of operating EGR at lower temperatures; (ii) the engine coolant temperature changing which Base Maps operate; or (iii) the application of the EGR temperature correction factor;

b) "*The effect of EGR modulation by air temperature on ECS effectiveness cannot be determined, as control boundaries were not evaluated due to limited range of ambient air temperature.*"

iii) In the context of FC1 during modified NEDC testing at -5ºC. NOx emissions had a CF of 1.15 times the regulatory limit; and an increase of 1.46 times the repeat Baseline NEDC. Thus the only test was well outside the NDC limits I have found, and Mr Carder accepted the results were to be *"expected given the technical limitations of EGR and the need for engine warm up"*;

iv) During modified NEDC testing at 5ºC, FC5 recorded a CF of 3.90 times the regulatory limit for NOx; and an increase compared to the repeat Baseline NEDC test of 2.08. FC5 also underwent a modified NEDC at 15ºC. NOx emissions were elevated to 1.17 times the repeat Baseline NEDC at Mahle, with a CF's of 2.20 times the regulatory limit.

v) For FD3, during modified NEDC testing at 0ºC, FD3 recorded a CF of 1.56 times the regulatory limit for NOx and an increase compared to the Baseline NEDC of 2.40. This is not a proper comparator for RIE because it is outside NDC. It does however suggest RIE at the limits of NDC would be within the CF's which Mr Carder accepted.

1066. It follows that it is not possible to say that the modulations by reference to air temperature adversely affect NOx output.

1067. The other aspects upon which the Claimants placed reliance were:

i) A "desktop" assessment of the EGR correction factors to find a submission that it can be inferred that the modulations have an adverse impact on NOx. However as Professor Millo explained lower air intake temperature also contributes to reducing the peak combustion temperature in the cylinder, reducing NOx formation irrespective of the impact of EGR. Therefore, a reduced EGR rate at low temperatures does not automatically equate to higher NOx emissions. Further Ford were applying the EGR derating in a staged way and it would be necessary to at least try to split out the effect of lower air intake temperature from the effect of the adjustment to EGR;

ii) Various internal Ford documents which discussed normal driving conditions and how to avoid regulatory risk. However none of these dealt with the effect of the temperature windows.

1068. Accordingly I am not persuaded that any of the Ford temperature windows were defeat devices and this element of the Claimants' claim fails.

1069. The questions of justification and alternative remedies thus present as double and triple contingencies.

Atmospheric Pressure

1070. The operation of the temperature correction factors for each CSV is:

i) FC1's EGR rate is reduced below 900 hPa (around 1,000m), with the full correction applied at 850hPa (around 1,500m);

ii) FC5's EGR rate is reduced below 900 hPa, (around 1,000m) with the full correction applied at approximately 825 hPa (around 1,750m);

iii) FD3's EGR rate is reduced below 950 hPa (around 500m), with the full correction applied at 853 hPa (around 1,500m);

iv) FD1's EGR rate is reduced below 950 hPa (around 500m), with the full correction applied at 850 hPa (around 1,500m);

v) For the base calibration, FC6's EGR rate is reduced below 950hPa (around 500m) with the full correction factor applied at approximately 850 hPa (around 1,500m). For the updated calibration, FC6's EGR ramps down from 950hPa (around 500m).

1071. It follows from the conclusions above that:

i) FC1, FC5 and FC6 update would not be DDs, even before considering RIE;

ii) FD3, FD1 and FC6 original operate a derate (though not a switch) just within NDC and, subject to RIE are capable of being DDs.

1072. However it is worth pausing to note that the conclusion that the devices straddle the line is uncomfortable in an area where the evidence from the experts agrees that (i) *"the MAFSP/ EGR rate modulation is required with intake air pressure"* (ii) the window in which all are operating is on the borderlines of where the need to calibrate for safe operation kicks in and (iii) where the border falls is a question of judgment. Indeed the experts agreed that *"The air pressure ranges listed are reasonable, well known in the public literature, and acceptable to use as a basis to modulate the ECS on air pressure"*.

1073. This may be thought to be another example of where the Claimants' approach operates as a blunt instrument and which provides another illustration of the practical advantages of the primary analysis.

1074. In any event, on RIE the evidence simply does not support RIE and the experts were not prepared to make that leap:

i) At paragraph 93 of his Report Mr Carder concedes: "…*Without a more comprehensive testing program, it is therefore not possible for me to give an opinion on whether the calibrations have been set appropriately in respect of these Sample Vehicles*.";

ii) Mr Carder stated at paragraph 401 in the section "*Alleged Air Pressure Defeat Device" EGR De-rating by Reference to Air Pressure*" that: "*The effect of EGR modulation by air pressure on ECS effectiveness cannot be determined, as control boundaries were not evaluated due to the limited range of ambient air pressure*.";

iii) Professor Millo considers at paragraph 14.7.4.1-14.74.2 of his Report that "*the application and logic of the air pressure correction factors are reasonable" "It is worth noting that these pressure values correspond to altitudes of approximately 500 m and 1500 m, respectively. In my opinion, this correction strategy is reasonable. In addition, the extent of the correction gradually increases with the altitude, as it is needed to compensate for the lower air density*."

1075. The Claimants rely on the axiomatic principle for RIE. For reasons already given this is not alone a basis for a conclusion on RIE.

LNT

1076. It is not in dispute that Ford calibrated the LNT in its LNT vehicles (FC6 and FD5) to regenerate at specified and predefined points in the EUDC phase during pre-conditioning and NEDC. The dispute between the parties is whether that calibration amounts to a DD and/or was justified.

1077. The Claimants say that by its LNT Strategy, Ford deliberately calibrated the LNT in FC6 and FD5 so that it would operate optimally during preconditioning and the NEDC test but not in NDC; such that regeneration was programmed to occur at fixed "predefined" points during the NEDC and its preconditioning phase, and then less frequently in many normal driving conditions, with calibration structured around the NEDC at the expense of NOx control outside it. The Claimants also argue that Ford deliberately suppressed regeneration during short trips, low-speed, and urban driving, reducing ECS effectiveness.

1078. In opening, the case appeared to be one which plainly resonated in the *"cheat device"* spectrum. It was essentially that LNT would never regenerate in real world driving conditions, while ace-ing the NEDC test. That is not the case which was argued in closing. That is because the reality was far more nuanced and was that the LNT would purge in real life, but less well/less optimally. The case in closing was that the vehicles were calibrated to purge (just) sufficiently to pass the NEDC test, but little in ordinary driving, resulting in a LNT that is impaired or useless because it is full, far less (and progressively less) effective as it fills, and where the purge fails effectively to reduce NOx. In sum, it is said the vehicles were calibrated to pass the test, but with little interest in or consideration of their real world performance.

1079. Ford's response to the Claimants' case was to focus on the rules-based operation of the LNT, and the fact that these same rules operated in real life. There was also much focus on the way in which the purge rules operate in real life, arguing that the LNT purging was far from being a "*when the stars align*" event, but a level playing field with the NEDC. Ford also emphasised the need for a purge on test, the lack of criticism from regulators and Mr Carder's somewhat less than hostile approach to the LNT calibrations – he regretted their lack of ambition to do better, *"design sign-off was assessed by successful durability demonstration at the selected calibration, without fully investigating what the actual limits were*". That "*should have done better"* approach was then seen in the Claimants' opening argument that "*the LNT was not being operated as effectively as it could be*".

<u>Test Cycle recognition?</u>

1080. The essence of the Claimants' case here was that there was an obvious temptation to calibrate to the NEDC test, and Ford (and the other LNT Defendants) failed to resist the temptation. In FC6, Rule 14 was said to be a CRDD. In FD5, Rules 14 and 15 were said to be CRDDs.

Calibrations

1081. It is common ground following the evidence that Ford did indeed calibrate the LNT system so as to ensure (i) purges in pre-conditioning and (ii) a purge in the NEDC test.

1082. A starting point is the flexibility of the LNT rule manager. There is common ground here, but the parties slant that ground in different directions. Mr Migliorero has described the LNT rule manager as "*complex*" but *"very flexible*", and "*open to customization*". Mr Migliorero accepted that, as a result, manufacturers can calibrate the LNT to find specific driving conditions at which a regeneration can take place.

1083. The Claimants rely on this to show an active choice to recognise the cycle, whereas Ford relies on it as part of the engineering judgement argument.

1084. The LNT rules are agreed between the parties via their experts, but are somewhat difficult to represent. Taking the pre-update FC6 as an example, there were three key DeNOx Rules (Rules 14-16). The active Bits or activation conditions for those Rules are highlighted in green below (courtesy of Mr Migliorero's report). Necessary terminology is: Long-term DeNOx Purge Ability ("LDPA") and Short-term DeNOx Purge Ability ("SDPA"):

i) SDPA encapsulates the driving conditions which need to be fulfilled for regeneration to occur. It is arrived at by considering catalyst temperature, positive torque gradient, engine speed and torque, gear and vehicle speed. The combination of these factors captures the probability of a successful DeNOx event. A higher SDPA value means that there is a greater chance of a successful purge. The Claimants say that the Ford calibrations for SDPA were too narrowly calibrated.

ii) LDPA was calculated from the average SDPA over a preceding period and was not criticised.

Bit	Description	R14	R15	R16
6	SDPA ability vs calibratable threshold	> 85%	> 50%	> 60%
	LDPA ability vs calibratable threshold	0	> 5%	> 8%
9	NOx load (%) of maximum loading capacity exceeding a calibratable Threshold	80%	80%	80%
21	time (min) since last regeneration greater than a calibratable threshold	5	5	4.5
22	distance (km) since last regeneration greater than a calibratable threshold	6	5	5

1085. The boxes in green are those enabled in the firmware. The greyed-out boxes are disabled in the firmware and not relevant to the calibration in the vehicle. The requirements of each rule are read downwards: for example, Rule 15 requires an SDPA ability of more than 50%, a LDPA of more than 5%, has no conditions as regards percentage of NOx load, and requires that 5 minutes and 5 kilometres have passed since the last regeneration.

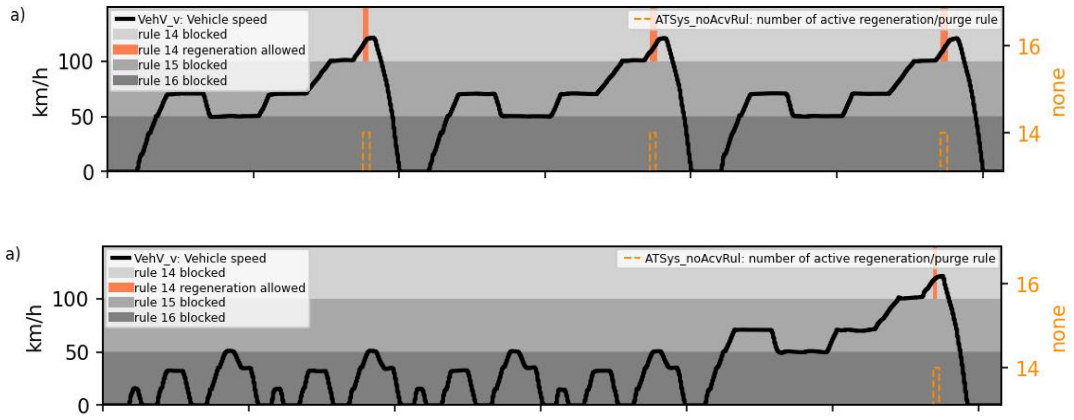
1086. The effect of these activation conditions was that:

i) Due to the LDPA activation conditions, Rules 15 and 16 were not triggered during pre-conditioning or the NEDC test, but can only be triggered during NDC;

ii) The only Rule which was triggered during pre-conditioning and the NEDC test was Rule 14. The SDPA (or Bit 6) – which encapsulates the driving conditions which need to be fulfilled for regeneration to occur – was narrowly calibrated. In order for a SDPA of 85% to be reached (under Rule 14), the vehicle had to be travelling at least 100km/h;

iii) The SDPA did not take into account the modelled level of NOx stored on the catalyst. There was therefore no requirement relating to the load of NOx on the LNT catalyst for Rule 14 to be triggered;

iv) As a result, during the preparatory drive of preconditioning, the LNT regenerated according to Rule 14 during each of the three EUDCs (as illustrated in the top graphic below), while during the NEDC test the LNT regenerated at a predefined point of the EUDC (as illustrated in the bottom graphic below), corresponding with the high-speed portion of the EUDC:



Cycle recognition

1087. In one sense the evidence is plain.

1088. The Claimants simply rely on the evidence that:

i) The purge strategy for Rule 14 was aligned with the Type Approval test procedure;

ii) The fact that Professor Millo accepted in evidence that there was "*no doubt*" that Ford was developing specific rules – the NEDC rules – to be triggered in the test;

iii) This is reflected in an August 2016 presentation, where Ford engineers noted that a calibration had been released without a calibration patch, the effect of which was that Rule 18 was being triggered on the NEDC, rather than Rule 14. The presentation observed that Rule 18 was "*wrong for NEDC*" as Rule 14 was the "*NEDC rule*".

1089. The Claimants are right that there is a form of cycle recognition happening in the Ford LNT calibrations. It does not however necessarily follow that it is offensive. As mentioned earlier in the judgment optimisation is not necessarily offensive, however it

is high risk because there is a point at which the exercise becomes not optimisation of something normal to the test, but the creation of a differential mode of operation for the test which is at high risk of being a defeat device. It does not follow of a certainty – for example if it is the only way to do something which must be done in the test. There may be other good reasons.

1090. That is what Ford say is happening here. In their submission there is however a wider picture which rather changes the perspective on this evidence. That relates to two things (i) the calculation of how to achieve a good purge and (ii) the need to purge in the test.

The good purge reasoning

1091. Taking the first of these first, it was clear that the SDPA is intended to capture the conditions in which a DeNOx event is most likely to be successful in reducing NOx. As Professor Millo explained, the rationale behind the SDPA conditions was determining when there will be "*good chances to perform a successful regeneration*". A bad purge is to be avoided if possible – at the least they waste fuel and risk CO_2 slip and there is evidence that (at worst) they lead to more NOx release overall: *"the consequence of not having a good purge event can lead to higher emissions, as you can see on some of the graphs…"*

1092. That calculation of how to get a good purge is based on the core physico-chemical and technical issues outlined in the summary of technologies and the technical appendix (essentially avoiding low LNT catalyst temperatures, avoiding excessively high LNT catalyst temperatures, stable operating conditions, rich operation combined with positive torque (accelerator depressed), thermal limits and combustion stability). Each of these elements has complications – thus the intention behind a time and distance requirement is to avoid overly frequent regenerations. Mr Carder accepted that the point of the time and distance criteria was to avoid the vehicle *"constantly purging"*. More purges are not better. The aim is the "*Goldilocks purge"*.

1093. The answer arrived at here therefore must (obviously) involve an exercise of judgement as Mr Carder's oral evidence made clear: *"the choice of calibration of LNT rules involve[s] an exercise of judgment"*. There is no single "right" answer.

1094. There were some suggestions by the Claimants that the window of conditions was not as complex or as narrow as Ford contended. For example they highlighted the fact that the minimum catalyst temperature was reduced in the 6.1M update and that at a later stage a vehicle was said to be able to operate its LNT below 200°C.

1095. The second of these points engages a theme seen repeatedly in the Claimants' case – pointing to updates and arguing that this could/should have been done sooner. The argument by reference to hindsight is one which must be considered with great caution. It cannot be a good argument to say that because something was achievable 5 years later, it could have been achieved 5 years earlier. An abiding theme of this case was that NOx control was on a journey, and this was an early part of the journey. Much ingenuity and money was being spent in designing and testing to improve as the targets tightened up. However it may be the case that the nature of the later change and the absence of development in the interim, combined with the nature of the device, can have some value.

1096. That is not the case here. It was not Mr Carder's evidence: he did not consider minimum catalyst temperature in either his Report or Supplemental Report. Although he suggested that Ford could have employed other technology, such as additional fuel injection or heating to increase the temperature of the LNT catalyst he did not in terms address minimum catalyst temperature.

1097. The change also did not impact on the optimum figure for regeneration, which on the evidence put to the witnesses remained unchanged with the optimum range for a DeNOx event starting at around 300°C. (The Claimants' late contrary suggestion relied on a document which was not cross-examined upon). It is hardly wrong as a matter of judgment to calibrate with a focus on purging in optimal conditions.

1098. Similarly the Claimants contrasted Ford's use of positive torque as a criterion with Renault's steady state approach; but this was not Mr Carder's evidence, and (as will be seen) the Claimants in turn criticised the Renault approach. It appeared rather that the decision to choose steady state (Renault) or acceleration for *"strong, positive torque"* was pre-eminently one of judgment and that either was a valid decision. It was not until closing that the Claimants moved to a suggestion that calibrations should have been done to purge in both situations, and there was no expert evidence directed to this.

1099. Dr Heitz's arguments which critiqued opportunistic purges like Rule 14 (and Rule 15) were not persuasive. Plainly one way of calibrating a purge is his preferred route, by reference to NOx loading on the trap; but there is obvious good sense (as the mechanical engineering experts agreed) in triggering DeNOx events when the conditions for a DeNOx event are good. It is hard to see why, if the conditions for DeNOx are favourable, a DeNOx event should not occur irrespective of the NOx load on the trap. Opportunistic rules of this sort "*make the most*" of the favourable conditions.

1100. The net result is that Rules 14 and 15 thus generally require a higher prospect of a good DeNOx event occurring than the lower SDPA of Rule 16. If, however, the vehicle has been driven for some time without the favourable conditions occurring such that the NOx load reaches the threshold set by Rule 16, then the SDPA is lowered so that a DeNOx event occurs, even if not in ideal conditions. The three Rules create a web which should ensure regular purges, one way or the other.

Need to purge on the test?

1101. The next point was the reasonableness/necessity of purging on the test. Here the Ford case was plainly one which had merit. Purely conceptually if the NEDC was being used as a proxy (however inadequate) for real world conditions, it should be expected that the LNT would purge during it. That conceptual/theoretical expectation dovetails with reality and the expectation of the authorities as reflected in the rules. The unchallenged evidence of Dr Davies was that the regulators also expected to see an LNT purge in the Test. Indeed, Ford may have had to explain to the regulators why a purge event did not occur on the NEDC; if there was not an LNT purge during the NEDC, that would be of note and of potential concern, because it would mean that in the higher load, and higher catalyst temperatures, experienced in the EUDC, the vehicle had not entered the conditions required to trigger a purge. That raises questions about the ability of the vehicle to purge on the road.

1102. There was a suggestion that if the vehicle only purged outside the NEDC test Ford would have to rely on a separate Ki factor which would negatively impact fuel economy figures. In fact the ki factor documentation assisted Ford in that it established that regenerating devices do not need a Ki factor if the manufacturer provided data to the type approval authority that during cycles where regeneration does occur, emissions remain below the regulated emission limits; thus providing for a regeneration within limits on cycle obviated the need for a Ki factor – reflecting the authorities' desire to see a regeneration.

1103. Similarly there was force in the Ford submission that LNT purges cannot take place all the time or indeed at "at any old time" (as Miss Nolten KC put it): there is a window and the manufacturers have to operate within the constraints of those windows.

1104. Here there is the clash between optimisation to the test and real world conditions. Miss Nolten KC's submission was that given that certain conditions had to be fulfilled in order to purge, what was the problem with choosing the best moment by reference to optimising test results. "*Since Ford knew that it needed to purge the LNT and could only do so in the narrow window in the extra−urban driving cycle, what is the problem with picking an optimal location based on its research?*" Mr Jaffey's submission that by definition choosing an optimal point meant less effective purging in the real world. To this Miss Nolten KC says that no factual basis has been offered to sustain that position and a rule which operates optimally in the test will also operate optimally outside the test when it meets the same conditions.

The absence of an urban purge

1105. This then takes the analysis to the real centre of the Claimants' case: that as a result of the operation of the DeNOx Rules, the LNT operated less effectively during NDC, particularly in urban and rural conditions. Further that in order for a SDPA of 50% to be reached (under Rule 15), the vehicle had to be travelling at least 60km/h (and at least in 3rd gear) and so in practice, this meant that the LNT could not regenerate in urban conditions. The result would be that if one drove these LNT vehicles only in urban conditions the LNT would never purge after its initial fill and NOx would simply pass through the system unchecked. That is plainly a highly unattractive situation. However at this point in development this appears to have been the settled understanding as to LNT purges – the other manufacturers with LNTs have vehicles which display the same behaviours. The Rule 14 purge has nothing to do with this; the vehicle still does not purge in urban conditions. What Rule 14 does is to create an extra condition which is guaranteed to produce a purge in test.

1106. In this case one of the points which was made was the difficulty of ensuring a purge in the period of time in which the test took place. The first four cycles of the Test are urban cycles which do not heavily exercise the engine, with the consequence that LNT catalyst does not reach the requisite temperature for a reliably efficient (as opposed to potentially inefficient/partial/failed) DeNOx event until the engine encounters the higher loads of the EUDC. This was a point made by Dr Davies in re-examination by the then Mr Moody KC: "*during the NEDC test cycle, the first part of it probably up to around 800 seconds, 900 seconds, the LNT temperature is just too cold [to] have [an] effective purge and also under those conditions it's really difficult to run a diesel engine rich as well, rich is required for LNT purging.*" Essentially the test gives only two conceptual possibilities for a good purge (at least when paired with acceleration) – at the acceleration into non-urban, and at the final acceleration to speed.

Rule 14: CRDD?

1107. On one level therefore it appears that Ford has created a special mode of operation in order to pass the test. Is this a defeat device? Potentially not if the mode created is one which is there for good reasons (i.e. not designed to cheat) and also occurs more than occasionally in real life.

1108. As to the former, the sections which precede this outline the wider picture in which the Rules stand. There genuinely were constraints as to when a purge could occur. It genuinely was necessary to purge in test. And a better solution (which assisted for urban driving conditions also) could not be created.

1109. As for the question of operation out of test, one is left with the difficult question of evaluating frequency based on fairly limited information. It certainly cannot be said that this LNT calibration answers only to the test; it is not set up to operate only in test as Mr Carder accepted. "*There's not a switch. We're not doing a Volkswagen technique of identifying the cycle and trying to say, yes, we're being tested on this*." Even the Claimants accept that if the right conditions are encountered, the Rule will be triggered.

1110. The Claimants however say that the frequency of operation of this rule is small – for Rule 14 to be triggered in NDC in the pre-update FC6, the exact same, very specific and narrow, conditions had to be met, including 6 separate conditions of catalyst temperature, positive torque, vehicle speed, engine torque, engine speed and time/distance constraints. Consequently a Rule 14 purge in real life will be, if not a unicorn, something like it.

1111. However that submission cannot be accepted, because the JTP did show the rule operating to purge FC6's LNT in real life on road testing. The chart below shows that in fact 2 out of 3 purge requests came via Rule 14 – and despite the utilisation of cruise control:

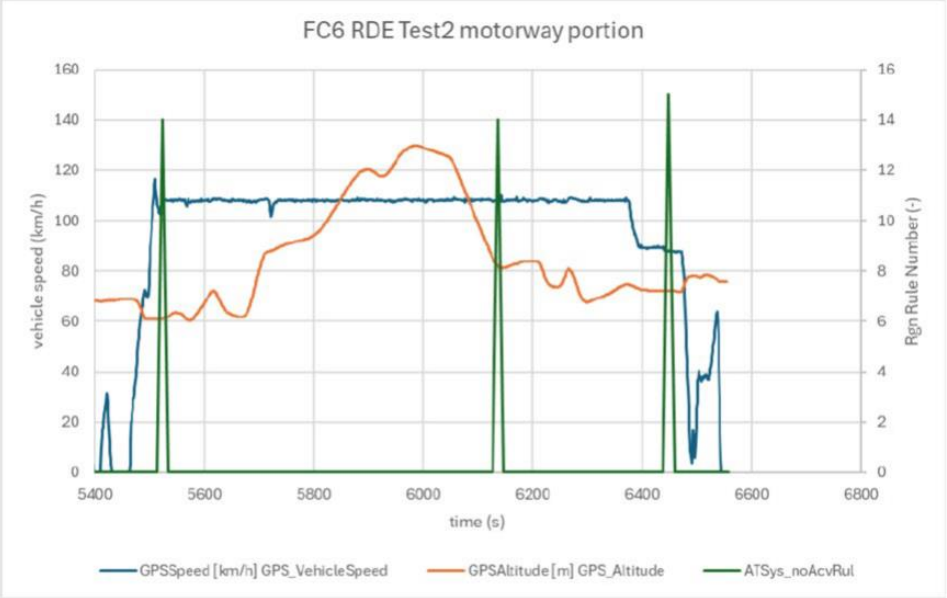


Figure 11.4 – Figure 34 of the Defendants' Software Expert Supplemental Report: GPS speed in Motorway portion of FC6 RDE Test2 of 2025 05 07 PM. Blue line: vehicle speed from PEMS GPS, orange line: altitude from PEMS GPS, green line: LNT regeneration rule active

1112. The on-road driving in which Rule 14 was engaged was a motorway cruise at a steady vehicle speed, a typical feature of everyday driving which confirms the on road effectiveness of Rule 14. This is to be contrasted with the circumstances in the NEDC where Rule 14 is engaged, namely, on the acceleration from 100kph to 120kph on a chassis dynamometer.

1113. Ultimately therefore the CRDD case fails in the light of:

i) Mr Carder's clear evidence: *"There's not a switch. We're not doing a Volkswagen technique of identifying the cycle and trying to say, yes, we're being tested on this."*

ii) The common ground that the rules operate the same in the Test and on the road. If the required conditions are encountered outside the test, there will be a purge.

iii) The JTP demonstrated multiple purges were requested pursuant to Rule 14 in FC6 in the motorway section of an on road test. For example on-road testing of FC6 there were three requests for DeNOx events in the motorway section: two pursuant to Rule 14 and one pursuant to Rule 15.

iv) The rationale which drove the construction of the rules and the tight constraints involved are established on the evidence.

1114. The evidence as to purging out of test to the Rule 14 rule also means that on the template analysis this rule was part of the available template.

1115. This is one of the most troublesome sections of this judgment, because of the sense that there is something fundamentally wrong with a set up where the LNT will not purge at all in urban driving – which we know from the NDC evidence is actually a very significant part of the driving done by real people in real life. However ultimately I am persuaded that this is really an argument with the technology itself, and that would be something for the drafting of the Regulation and its testing process or even for the Type Approvals process itself. What has happened in the years which have passed has effectively driven advances in the NOx trap technology and a move to SCR technologies. LNTs of this vintage, where not falling within the PDD definition have to be regarded as sub-optimal staging posts.

Standard defeat device?

1116. There was no clearly delineated "standard" defeat device analysis pegged to testing for reduction in effectiveness. The JTP testing for these vehicles produced anomalous results (including an NEDC baseline fail for both vehicles). In part this was because it transpired that the Ford LNT vehicles had been afflicted with a serious problem, called the DeSOx Defect.

1117. When present in the combustion chamber, sulphur, which is contained within the fuel, will form SOx. SOx is an inevitable by-product of sulphur in diesel fuel and lubricating oil. When SOx passes through the LNT, it reacts on the platinum in the washcoat, forming a sulphate on the same sites used to trap NOx. Once occupied by SOx, the sites are not available for occupation by NOx. SOx therefore will gradually reduce the availability of NOx storage sites on the LNT, in turn reducing the ability of the LNT to store NOx.

1118. SOx removal is challenging. It requires generating very high temperatures over the LNT catalyst (higher than in a normal LNT regeneration) together with rich conditions. Ford's original calibration initiated DeSOx purges after DPF regeneration, making use of the higher temperatures required for a DPF regeneration. Ford identified in late 2016/early 2017 that DeSOx events were not occurring frequently under certain driving conditions, or were being interrupted, with the effect that the SOx gradually built up on the catalyst.

1119. Ford developed an update to the calibration for affected vehicles over about 12 months which would implement a more robust ongoing desulphurisation and purging process during operation of the vehicle, ensuring that accumulated SOx would be removed from the system, rather than being allowed to build up on the catalyst. FD5 received the update after about 11,900 miles. FC6 had not received the update prior to litigation testing but the update was applied during testing. This obviously had an impact on the robustness of the testing.

1120. The Claimants have relied on DeSOx in support of a draft amended case that the LNT was defective with the result that affected vehicles ceased to conform with their type approval. That case forms no part of this trial.

1121. The position therefore rests here. There is no reliable relevant testing. However it is apparent that because of the nature of the LNT regeneration process and the approach taken to accommodating other pollutants and issues the LNT would only purge in fairly limited conditions. The key point is that as a result of the operation of the LNT and the DeNOx Rules, the LNT operated less effectively in real life, particularly in urban conditions. Even during NDC, in order for a SDPA of 50% to be reached (under Rule 15), the vehicle had to be travelling at least 60km/h (and at least in 3rd gear). Dr Davies accepted that, in practice, this meant that the LNT would not regenerate much, if at all, in urban driving, it would however still store NOx. Mr Migliorero accepted that the vehicle would not regenerate in urban driving for example if the vehicle was driven around cities such as London, Paris or Rome. The result was that the LNT would be useless once full in such conditions.

1122. That is, in my judgment, a reduction in effectiveness.

1123. For completeness mention should be made of the following points:

i) The Claimants' case was also that purging was also marginal or often ineffective in rural driving. However there is no case, separate from the CRDD case as to the inadequacy of the purging of the system generally.

ii) Finally there was the question of whether Ford could or should have done better. However that is not a pleaded case, and can be relevant only to inferring a differential intention. Further the Claimants had no positive case on this, save to say that the later changes pointed to what could have been done at the time. This returns the argument to the 6.1 update, and was not sufficiently focussed to be a good argument.

SCR

1124. The Ford SCR allegations relate to AdBlue dosing strategy in FD1 (the only Ford CSV with an active SCR system). Ford calibrated the SCR in its SCR vehicles to modulate the

urea dosing such that the quantity of AdBlue injected into the exhaust system was restricted to a Urea Dosing Limit or UDL. The dispute between the parties is whether that calibration amounts to a DD and/or was justified. This is not said to be a CRDD: it is agreed that it does not function differently inside the Test from how it functions outside.

1125. It is perhaps telling that the Claimants' Opening treated this alleged DD very lightly; and that in Closing the submissions are likewise fairly short, and with no real focus on RIE.

1126. In outline the features of the SCR dosing system were:

i) The quantity of AdBlue injected into the exhaust stream in FD1 was restricted to a UDL, determined by reference to the exhaust mass flow, exhaust gas temperatures, and SCR catalyst temperature. This is described by Ford as a feed-forward dosing model; i.e. it uses exhaust gas temperature and exhaust mass flow as proxies to model the amount of ammonia stored on the SCR catalyst;

ii) A transient correction factor (of up to 2.5 times) could be applied by reference to a torque derivative, with the result that the UDL (and therefore the quantity of AdBlue injected) could be increased briefly at higher rates of torque change.

1127. The Claimants therefore say that, despite the transient correction factor, the effectiveness of the SCR is still reduced in higher speed conditions which are more representative of normal vehicle operation and use the effect of which was that in real world driving insufficient AdBlue would be dosed to treat the NOx emissions and the calibration is therefore a DD. There is a second strand to the SCR case namely that that urea injection is reduced in FD1 "*in conditions which could reasonably be expected to be encountered in normal vehicle operation and use, including during heavy load carrying or towing up a significant gradient, in order to avoid, inter alia, DEF Consumption*".

1128. A UDL sounds, on the surface like a bad thing. But there are ways and ways of limiting. A blanket limit might be difficult to justify. But the way a limit works has to be considered in the light of the way an SCR system works. It is not an entirely simple system. The relationship between "urea in" and "NOx out" is not linear, as Mr Carder agreed: "*Q: …we can't simply say that if the system is pumping in urea at the top end, less NOx will be coming out of the tailpipe at that moment? A: You can't say that*".

1129. As outlined above, it is critical to the success of an SCR that its efficiency depends upon the amount of ammonia adsorbed onto the catalyst, and is available to react with NOx. If there are high levels of stored ammonia injecting more urea is not necessary. A system which therefore works out (or tries to work out) how much ammonia is stored and injects urea only to the extent that it is necessary is not a bad thing. If it works, it achieves efficient NOx reduction and does not waste the driver's money on more AdBlue than is actually needed. Indeed the converse, injecting excessive AdBlue in unsuitable conditions, can cause excessive deposits and a real risk of the engine shutting down, compromising vehicle safety.

1130. This is the essential problem for the basic iteration of the allegation. It is wrong to say that a UDL is a bad thing. The Ford experts indeed agreed in terms that "*Dosing and effectiveness is not a one-to-one relationship. NH_3 storage has to be considered in the effectiveness of the NOx reduction... Over-dosing causes ammonia slip... SCR dosing*

does need to be modulated". Mr Carder accepted in cross examination that the imposition of a UDL does not mean that SCR effectiveness is reduced.

1131. As for the means chosen to calculate this dosing regime there was no real expert criticism of the route chosen. The judgement that Ford's engineers exercised in arriving at FD1's SCR design and calibration used at type approval was effectively agreed by all the experts to be reasonable when considered from the perspective of Ford's engineers at the time, not with hindsight.

1132. Mr Carder tentatively suggested an actual NOx sensor might be an idea if available, but that was a suggestion which gained no traction. In oral closing the Claimants accepted in terms that: "*We all agree that a urea dosing limit is a perfectly legitimate thing*" and sought to suggest that this was all about Article 5(2)(a) and ammonia slip. However that is a cart before the horse approach – first is the question of whether there is a DD at all. This depends upon establishing a RIE. That has not been done.

1133. The nearest approach was Mr Carder's evidence on the JTP, including that ECU data from the JTP, demonstrates that (i) the UDL caused a reduction in effectiveness and (ii) despite the uplift possibility the quantity of AdBlue injected was still restricted by the UDL during the higher speed portions of the NEDC test. However Mr Carder fairly accepted in his evidence that the tests were not sufficiently conclusive to form a reliable dataset. There were good reasons for that agreement.

1134. The FD1 JTP results were inconsistent and confusing. All FD1 test results, including baseline NEDC tests carried out on both the pre- and post- firmware update versions failed the NOx emissions threshold: i.e. exceeded the 125 mg/km limit. On road testing for the updated firmware resulted in CFs between 2.62-9.74 times the regulatory limit for NOx; and an increase of 1.57-5.84 times the NOx levels from the Baseline NEDC test. In each case the post-rollback (i.e. original) software performed better than the update. NOx emissions for dynamometer tests carried out at 10% higher speed showed reduced NOx emissions when compared to the baseline NEDC Test result. This led to a suspicion on Professor Millo's part that the vehicle might have a compromised ECS (such as a damaged or excessively aged catalyst). Both he and Mr Carder agreed that it would have been sensible to replace the vehicle or replace some parts. There were also concerns over the conduct of the testing – the absence of continuous emissions data, and Professor Millo's view (not actually dissented from by Mr Carder) was that other factors such as inconsistent preconditioning (leading to different ammonia storage levels), a lack of repeat testing, and inconsistent testing approaches between Ricardo and Mahle could be at the bottom of the puzzle.

1135. Thus the tests gave no basis for supporting the Claimants' case, in that they were not robust. Moreover one of the featured noted above (better performance in NEDC +10% would suggest better performance out of test than in it, contrary to the Claimants' case. Mr Carder's other arguments on this (by reference to conformity factors with moving average windows) suffered from the same deficiencies noted in relation to the speed/torque arguments.

1136. Nor does the fact that this strategy was the subject of an AES/BES submission mean that it was a defeat device.

1137. Finally the Claimants' ultimate case – that urea dosing should be conducted stoichiometrically to maintain a filled catalyst was not a pleaded case, nor one put to the witnesses.

1138. As for the second iteration of the SCR allegation, although pursued as far as written closing no further argument was addressed to it by them. That was doubtless because on the evidence again no DD could be established given that:

i) The UDL was not calibrated to reduce urea injections when carrying loads, towing or travelling up a significant gradient. It was calibrated so that its UDL would increase the amount of urea dosed under higher-load conditions in two respects;

ii) Under heavier-load conditions, there is an increase in FD1's engine torque. The increased torque necessarily requires the engine to work harder to generate additional power. As a result, exhaust gas temperature and exhaust mass flow increase. Increases in exhaust temperature and exhaust mass flow generally lead to higher initial UDL values;

iii) The initial UDL is further increased by application of the UDL multiplier in heavier load conditions.

1139. It follows therefore that taken overall in conditions reasonably to be expected in normal vehicle operation, including heavy load carrying, towing, or driving up significant gradients, urea injection appears more likely than not to increase rather than decrease, in consequence both of the upward trend in initial UDL values with exhaust temperature and mass flow, and the effect of the UDL multiplier.

1140. On this basis Article 5(2) does not arise, but I note for completeness that Dr Heitz conceded that the UDL is substantially witnessed in the test, giving rise to a defence under Article 5(2)(c).

Sixth Gear

1141. The Sixth Gear allegations are to some extent a variation on the theme of the Torque/Speed DD allegations already considered. However it has a separate life, which is related to two features of the facts:

i) The NEDC was designed to be run in gears 1-5, though using sixth gear was optional;

ii) If one shifts into a higher gear, this will tend to occur at a point of high engine speed. At that moment:

a) The torque available is increased -which will tend to result in EGR modulation;

b) At the same time for a period of time engine speed will fall sharply;

c) The consequence will tend to be a sharp temporary rise in NOx.

1142. So far as concerns standard torque/speed modulation issues there is therefore nothing to add to the earlier section. The question is rather one which is directed to the specific

features of (i) choosing not to use sixth gear in the NEDC test and (ii) the potential consequences for EGR rate when the vehicle shifts into sixth gear in real life. The Claimants say that NOx performance in sixth gear is worse because of the torque/speed modulations, and that by not deploying sixth gear in the NEDC test the sixth gear effectively becomes a PDD.

1143. The starting point for the Claimants' concerns can probably be found in the 2017 VMSU investigation, which recorded that an unintentionally modified NEDC test on a Euro 5 Transit (of the same variant as FC5) resulted in NOx emissions over twice the legislative limit. Ford explained that the high levels of NOx emissions were due to the fact that the VMSU had (as recommended by the vehicle's Gear Shift Indicator ("GSI")) used 6th gear during the test, where the use of 6th gear during the entire NEDC test was not mandatory at the time. In a contemporaneous email, Ms Tamzen Isacsson (Director of Communications and International) asserted that it was "*[p]erfectly legal for Ford to specify the vehicle should be tested in 5th rather than 6th so nothing non-compliant, but obviously not viewed well by DfT*". A re-test which did not go beyond 5th gear resulted in a pass.

1144. The Claimants say that this was consistent with Ford's internal testing, which demonstrated that the NEDC was passed in a 5-speed shift schedule, but the effect of engaging 6th gear in the last acceleration of the NEDC test (for a period of only 20 seconds) resulted in NOx levels doubling across the entire NEDC test

1145. The Claimants contend that Gear 6 (unlike Gear 5) had not been optimised for the test and so generated "off cycle" performance bad enough for its period of engagement to double overall emissions.

1146. Ford's response (aside from noting that the regulators let matters lie on this basis) is that the result is perfectly explicable and does not demonstrate that using 6th gear outside the test results in higher NOx such that 6th gear becomes a DD.

1147. Ford's case is that if 6th gear is deployed in the NEDC test (which has to be driven to a very precise set of speeds and times, hence the "ketch" shape) it creates an anomalously bad situation. This can be summarised as follows:

i) At the moment of the shift to sixth gear, torque spikes as the higher gear is engaged but engine speed also falls sharply. Thus, the vehicle operates for a very short period in an area of high torque and high engine speed, which is incompatible with EGR;

ii) The sixth gear operating point decreases engine speed but increases torque, thereby pushing the vehicle towards an area of component concern, i.e. turbocharger compressor surge;

iii) In normal driving these conditions operate only briefly: as the driver starts to build the engine speed up, torque will decrease (because the acceleration ceases). This returns the EGR into a more normal operating area;

iv) In the specific and unusual context of the NEDC however, this last acceleration and shift to sixth gear is followed by a sharp coast down and a key-off event. That creates an anomaly, explained by Dr Davies: "*If somebody was accelerating from*

fifth gear from 100 to 120 kph, it would be a very, very rare occurrence that that person would then stay or would very shortly come back to a rest."

1148. On occasion here the Claimants' case seemed to equate to saying that sixth gear per se is a cheat device. This argument, which leads to an implicit requirement to have a bigger engine, so you do not need sixth gear, is one of the interesting manifestations of the "dream car" analysis.

1149. The point made by Ford is that an argument that a decision not to type approve in sixth gear would mean that a vehicle had reduction in effectiveness in real world driving, and therefore it was axiomatically a defeat device would be a ludicrous regulatory outcome, given that testing in five gears is permitted.

1150. It follows that a result gained in an NEDC test should not be taken as representative of the results to be expected of 6th gear operation generally. True it is that a real world driver would use 6th gear when prompted by the GSI and that would result in a temporarily worse result at the exactly matching point; however that should not be taken as establishing RIE because unlike the test it would be unlikely that the driving would stop very shortly afterwards. To do a direct read across would be to follow the "julienning" approach. In real life, the EGR rate would increase again and the effect of the short spike of NOx would be lessened.

1151. The question in my judgement is really whether it would be ironed out as Dr Davies suggested:

> "Yes, there's a high spike of NOx under that acceleration event, but then if the driver was driving for a longer period, which you would expect for the drive conditions of that acceleration, then the NOx would be averaged out over that longer time period and distance factor".

1152. At the theoretical level Professor Millo and Mr Carder accepted in their Joint Statement that use of 6th gear would increase engine torque demand, so that "*EGR rate will have to be reduced*", likely increasing NOx. That however simply leads back to the issues considered under torque/speed and is not sufficient to drive a conclusion.

1153. So far as concerns reducing EGR rate generally in sixth gear there is a tension in the evidence. Mr Carder did not advance a positive case on this saying: *"… I am not able to fully assess the impact [of] the effect of 6th gear on the NEDC test cycle as laboratory-to-laboratory variability limits the comparison for this Vehicle."*

1154. That ambivalence reflects the fact that on the one hand, the JTP results produced an NEDC test run on FC5 using 6th gear. The test data from Mahle evidenced a 6% decrease in the levels of NOx emissions from the repeat Baseline NEDC; but there was an approximate 82% increase from the Repeat Baseline NEDC conducted at Ricardo. At the same time while FC5 passed the Baseline NEDC on 8 April 2025 at Ricardo, it failed the same test by a significant margin at Mahle. These results indicate "*significant variability*" between the laboratories, and the limited evidence on this suggested it was likely to be down to issues at Mahle (testing with bonnet open not closed and "poor fan positioning"), not Ricardo.

1155. The other evidence relied on was that of the VMSU which tested a Euro 5 Ford Transit of the same variant as FC5, engaging 6th gear when prompted by the GSI in the higher

speed portions of the NEDC. This resulted in NOx emissions over twice the regulatory limit. While as Ford pointed out the experts did not have the underlying data so as to be in a position to analyse it; or any information in respect of the condition of the vehicle used, they had run their own re-test submitted to the regulators which itself appeared to replicate not just the spike but also the extent of the spike if 6th gear was run.

1156. I bear firmly in mind that in test the short acceleration in sixth gear doubled the level of emissions over an entire 20 minute test and that this suggests, as the Claimants say, that sixth gear accelerations are of disproportionate importance to overall NOx emissions. However ultimately I accept the submission that there is no safe evidential basis for concluding that the use of sixth gear in NEDC is a PDD or that operating the vehicle in sixth gear on the road leads to increased NOx in general.

1157. Not using sixth gear in test was permitted and effectively followed from the requirement to follow the trace for the NEDC test. The precise extent of the spike which would be caused by using sixth gear in the test is unclear on the evidence, but there is some basis for concluding it would be a significant spike, albeit in a short period. Comparing the in test fragment with out of test sixth gear driving is not a fair comparison, because the gear change produces a short spike caused by the torque/speed disjunction in a gear shift, and sixth gear driving will tend to take place over a longer period. There is no evidence as to the effect of prolonged sixth gear driving, still less evidence which splits out whatever inevitable and permissible effects there are of higher speed driving. The evidence is a jumble. It does not permit a safe conclusion that there is RIE.

THE PCD CSVS

CSVs and summary

1158. Peugeot, Citroën, and DS are three French motor brands which were ultimately owned by French multinational the PSA Group until 2021, when the Stellantis group of companies was created as a result of a merger with Fiat Chrysler. The Stellantis group now owns 14 motor brands of which 9 are the subject of Pan-NOx litigation.

1159. There are four CSVs, each of which has the same DV6 1.6l engine:

	Model	Model year	ECS technologies
PCDC6 (Euro 5)	Citroën C4 Picasso	2014	HP EGR
PCDD4 (Euro 5)	Peugeot 2008	2015	HP EGR
PCDC3 (Euro 6)	Citroën C4 Cactus	2015	HP EGR & AdBlue SCR
PCDD1 (Euro 6)	Peugeot 2008	2018	HP EGR & AdBlue SCR

1160. For the Euro 5 cars the DDs alleged were as follows:

i) The following EGR derating PDDs: Torque and speed (the "Torque/Speed DD"); IAT (the "Thermal Window DD"); air pressure (the "Air Pressure DD"). These are largely familiar in outline to DDs alleged in other cases.

ii) A "Split Injection Timing DD". This is the unique DD alleged in relation to PCD and it is said to be a CRDD.

<u>Backdrop: the ghost at the feast</u>

1161. A piece of necessary background to the PCD DDs is that in relation to Euro 6b, PCD's CSVs have two engine mapping modes: EOM1 and EOM2 (also sometimes referred to as "Mode 1" and "Mode 2" – or by the Claimants as LowNOx and LowCO_2 modes). The selection of EOM1 vs EOM2 is dependent upon a number of factors, including in particular ambient air temperature and ambient air pressure. However the Claimants already had a modes-based case relating to the Euro 6 vehicles – and that is now said to be a development of the Euro 5 case with changes made to the parameters for operation away from the actual boundaries to make the "*appearance of the "defeat device" less obvious and visible*".

1162. The remaining issues on them are relatively limited. However there is a good deal of material which surrounds them, because shortly before trial, as noted above, I refused permission for an amendment by the Claimants to allege that EOM/Mode 1 at Euro 5 was "*dedicated to the precise parameters of the NEDC alone"* (i.e. was a *Crossley* type switch device). That allegation could not be prepared for in time for trial and therefore will be determined separately. Despite my ruling, the Claimants (who argued in support of letting their amendment in that the allegations were necessarily there via the Euro 6 case and that argument on Euro 6 could not properly be conducted without looking back) have repeatedly defaulted back to discussion of the Euro 5 Combustion Modes

allegations, adducing evidence which goes to this, and on occasion cross-examining with an eye on those allegations.

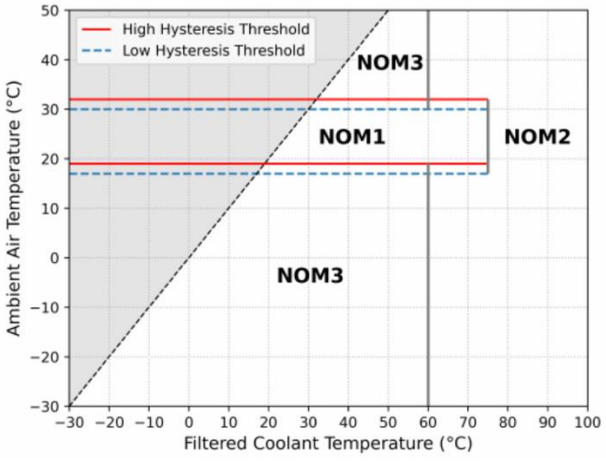
1163. Those issues are not before me in this trial. That was a decision taken because I was persuaded that PCD could not properly prepare to fight those (very serious) allegations. Accordingly PCD have not tried in this trial to run a full case on the allegations. However, to reflect the way the Claimants put their case it is necessary at least to record what case the Claimants intend to run on this and how that fits with the Euro 6 combustion modes case.

1164. Thus the Claimants say that PCD was imbued with a culture of cheating. They allege that:

i) In the NEDC test, PCD cheated the CO_2 score, and inflated the apparent fuel economy, for its pre-2016 (i.e. pre-Dieselgate) Euro 6 vehicles - including PCDC3 - by an electrical management strategy which detected the pre-conditioning of the NEDC test, triggering the battery to charge to its maximum level. Then, when the NEDC began, "Warm-up mode" was triggered whereby battery charging was artificially turned off for the length of the test and the vehicle relied on stored energy. This artificially reduced the engine load demanded during the test, so less CO_2 was emitted and less fuel was consumed, whereas outside the test, the battery would recharge if it dropped below a charge of 85%, by a strategy called "BBN" or "Bilan Batterie Nul";

ii) Outside the NEDC, other strategies were aimed at reducing real world CO_2/fuel consumption at the expense of controlling NOx;

iii) In particular PCD's Euro 5 strategy involved "LowNOx mode" (EOM 1) being applied only in the temperature range at which the NEDC was conducted, and so-called "LowCO_2 mode" (comprised of EOM 2 and 3) applied outside it. The functioning of these modes at Euro 5 timeline is said to be as follows:



iv) It is said that at the time of Euro 5 to the parameters of EOM 1 were almost identical to the NEDC conditions and that PCD internally described this mode as "*dedicated to application in the conditions of the [NEDC]*";

v) For Euro 6, it is said that:

a) The pre-Kaizen NOx Euro 6 vehicles, which Mr Lesueur said comprise 5-10% of all Euro 6 vehicles sold, have the same temperature parameters of 17/19°C -30/32°C (i.e. the boundaries of the NEDC) and also uses test-dependent timers (one measuring time, and another measuring filtered ECT);

b) The aim was later to move the customer from LowNOx mode into LowCO_2 mode "*as quickly as possible*".

1165. The Claimants allege a variety of other "cheats" regarding battery life, in service conformity and so on. Again however those are not part of the issues for trial and full evidence was not heard on them.

Witnesses

1166. Mr Lesueur the first PCD factual witness was a dogged, quietly spoken witness who (perhaps with the benefit of extensive experience in regulatory investigations and litigation elsewhere) largely kept his patience during a long and testing cross examination. His patently genuine exasperation however occasionally rose to the surface, and he was prepared to defend the PCD approach with some animation. It is fair to say that he came across as a polished witness and that occasionally he appeared to be saying something he had said before. But his belief in the truth of what he said was plain to me. If he was inaccurate, this was, I am sure, down to the effects of the passage of time and repeated need to recall details, with the deleterious effect that is known to have on real memory. There were some aspects of his evidence which did spill over into expert evidence.

1167. Mr Chappelle, the second PCD witness, was an urbane and sophisticated witness whose casual gestures of the hand conveyed a relaxed sincerity. He was the author of one of the best *bons mots* of the entire trial "*...nature is not generous in all aspects. So when you develop an engine, you have always to make compromise*." He did occasionally however present as quite determined to tell his story, whether because he was not focussing on the questions which were asked or because he had understood a broader question to be asked. There were also occasions when he appeared to misunderstand the nature of the exercise of being cross-examined.

1168. The Claimants' mechanical engineering expert was Professor Martinez-Botas the current head of the department of Mechanical Engineering at Imperial College London. He was a relaxed and knowledgeable witness. Mr Taylor's attempt to dispute his expertise was doomed to failure, although he frankly admitted that he was not a combustion engineer and on occasion his approach was a little too theoretical or academic (for example as to some cutting-edge technologies never actually deployed in real life). While he was refreshingly willing to answer questions with which he agreed with brief answers, or even a simple "correct" where he was conceding a point, he fairly often evaded the simple answer to the question, providing a longer answer which tacitly, but not explicitly, conceded. He was also on occasion rather chatty and discursive, as if he was not sure where a question was going or if an amusing thought occurred to him in the course of giving an answer.

1169. Over the course of his evidence it was apparent that despite his undoubted academic excellence and expertise he had made a number of mistakes. He was hardly alone in this

– given the pressure of time and the complications, schedules of corrections were rather more often seen in this case than is normal. However some of these mistakes were fairly serious. The impression was left that Professor Martinez-Botas had, as regards some portions of his reports, relied too fully upon his research assistants and had not checked their work with complete thoroughness.

1170. PCD's mechanical engineering expert was Mr King. Contrary to the Claimants' characterisation of him as something of a doom-monger, he was an extremely amiable, expressive witness whose cross-examination by the equally lively Mr Kramer (accompanied by expansive arm gestures on both sides) sometimes felt more like a voluntary engagement between like-minded people than a conventional evidential clash.

The Split Injection DD

Description

1171. Split mode is a combustion mode in PCD's Euro 5 vehicles in which the main injection by which fuel is injected into the combustion chamber is split into two, with a delay, or a "dwell" in between.

1172. The way that the device operates is not contentious; the first part of the case advanced by the Claimants is made out by the evidence.

1173. In essence there are 7 main parameters for the activation of split mode, all of which must be present for split mode to activate. In addition there are three extra aspects: Timer, a deactivation threshold which the Claimants refer to as the "kill switch" and mode prioritisation. The 7 parameters are as follows:

Criterion	PCDC6	PCDD4
Ambient Air Pressure	> 875 / 900 hPa	> 910 / 920 hPa
Intake Air Temperature	12 / 18°C to 35 / 45°C	15.5 / 17°C to 41 / 42.5°C
Coolant Temperature	25 / 75°C to 90 / 95 °C	71 / 73.5°C to 86.5 / 89°C
Fuel Temperature	0 / 13°C to 40 / 50°C	15.5 / 17°C to 46.5 / 49°C
Vehicle Speed	60 / 75km/h to 124 / 128km/h	71 / 73.5km/h to 121.5 / 124km/h
Engine Speed (Maximum and Minimum)	1450 / 1500rpm to 2900 / 3000rpm	1475 / 1525rpm to 2438 / 2563rpm
Torque Demand (Maximum and Minimum)	0 to 220 / 240Nm	50 / 60Nm to 177.5 / 182.5Nm

Thermal Energy Consumption	0 to 110J	0 to 60J

1174. Those parameters coincide with the highest load phase of the EUDC (and thus the period of highest engine out NOx), as can be seen from one of Dr Heitz's diagrams reproduced below. It shows that the vehicle speed (shown in purple) and engine speed and torque parameters (shown in pink) for split mode perfectly align with that phase, and the ECT parameter (shown in orange) is only satisfied just before the start of the EUDC.

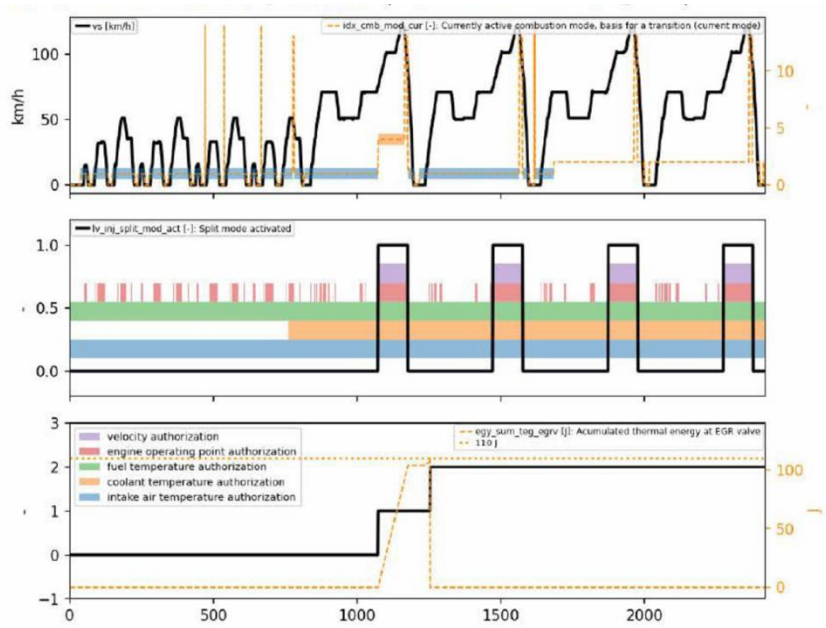


Figure 44. Euro 5 Split authorisation - PCDC6.

1175. To some extent the Claimants present the argument on this issue as self-evident: the precision of the alignment is posited as a "smoking gun" which taken even alone, but certainly together with the contemporaneous documents, establishes this as a CRDD.

1176. The Claimants therefore note the specificity of the tailoring - that despite the CSVs having slightly different parameters, split mode triggered only three seconds apart in the JTP baseline NEDC tests: at 1,034 seconds for PCDC6 and 1,037 seconds for PCDD4. Internal testing carried out by PCD on other Euro 5 vehicles (some of which have different engine types to the CSVs) shows split mode triggering at precisely the same point of the NEDC (e.g. testing on a DW10 engine, a larger engine than the DV6 used in the CSVs, and the four NEDC tests show split mode triggering just before or at 1,040 seconds into the test).

CRDD?

The primary purpose of split injection

1177. PCD's design intention was that in the NEDC cycle, its Euro 5 vehicles would only be in either Mode 1 or split mode.

1178. The contemporary documents show that the profile and correlation of the split injection was by design and not by chance; but what underpins that choice is highly contentious.

1179. The Claimants of course seek to suggest that the intention was a purely nefarious one. In closing the Claimants sought to rely on a presentation of work done by the Clean Mobility & Thermofluids Institute at the University of Valencia, where Renault's experts Professors Plá and Benajes are based. That document dated 5 July 2005, was the CMT's presentation of its "Low NOx Combustion on Diesel Engine" concept to PCD. The Claimants highlight reference to objectives including "*very low NOx emission*" and "*very low combustion noise*", amongst others, noting that "*because of [the DPF] and [DOC] high soot, HC and CO are tolerated*." The conclusion on page 19 states that "*an injection-combustion mode has been found that: reduces NOx and soot emissions*" and "*reduces combustion noise*".

1180. PCD objected to the very late reliance on the document, which was not put to any witness. It was right to do so. The evidence adduced and considered by the experts led to an agreement between the experts that the primary purpose of splitting the injection in this way was to reduce combustion noise and to reduce soot. Mr Lesueur explained in evidence that split injection "*was designed for reducing the noise and particulate emissions included on NEDC*"; soot is a particular concern in diesel vehicles because of the DPF. Splitting the injection reduces the violence of combustion, which in turn reduces the pressure gradient during combustion and the temperature in the combustion chamber. Split injection's parameters of operation were targeted at engine conditions which would otherwise produce significant noise or soot emissions. Split injection was used for the first time in some of PCD's Euro 5 vehicles and it was calibrated around concerns about the durability of the fuel injector system because of the wear that it may cause to the injectors. The experts agreed that because split injection was developed for Euro 5 vehicles, there was limited knowledge regarding the impact the use of split injection would have in terms of fuel injector durability.

1181. The primary purpose of this device was therefore to reduce combustion noise and reduce soot, while also managing risk around the new approach. It was not a device simply designed to "*cheat the system*".

1182. This conclusion does not mean that the device cannot be a CRDD. But it means that the evidence does not demonstrate that this was the primary motive of the device.

Availability outside NEDC

1183. It is not seriously disputed that it was also the design intention that the use of split mode should be limited outside the NEDC test. E.g. the philosophy document states that the calibration should "*avoid transition from hot mode to split mode*". Hot mode (mode 2) never applies in the test.

1184. But there is a hotly fought issue as to the extent to which the mode applies out of the test. The Claimants' starting position was to allege that split injection is only used when the ECU detects the parameters of the EUDC stage of the NEDC test, or closely aligned parameters; and that the use of split injection lowers NOx emissions. They alleged at that point that split injection is not activated outside of these parameters.

1185. As PCD emphasised, this absolute version of the argument cannot succeed. Split injection does activate outside of the EUDC stage of the NEDC in NDC. The experts agree that:

i) Split injection was active during the two US06 tests performed on PCDC6. On the first US06 test, split injection activated twice, for 99 seconds from 222 seconds and for 2 seconds from 327 seconds. On the second US06 test, split injection activated once for 110 seconds from 210 seconds;

ii) Split injection was active twice during the WLTC tests performed on PCDC6, for 87 seconds from 1198 seconds;

iii) Split injection was active twice during the two US06 tests performed on PCDD4, for 8 seconds from 205 seconds and for 11 seconds from 226 seconds;

iv) Split injection was active twice during the WLTC tests performed on PCDD4, for 2 seconds from 687 seconds and for 1 second from 868 seconds.

1186. PCD therefore contend that the facts of primary purpose and that split injection operates outside of the test mean that it is wrong to say that split mode is a CRDD. PCD says that split injection is activated primarily to address noise and soot and so at the point in the test when this is a greater concern; it is then deactivated in order to prevent damage to the injectors. It is not "designed to" cheat the NEDC test.

1187. Nonetheless it is perfectly possible to see why this device has caused suspicions on the part of the Claimants. In the JTP road tests, split mode did not activate at all for PCDC6 principally because the vehicle was not in mode 1. The vehicle was in Mode 2 for the vast majority of the time. Out of the c.12 hours of road tests, Mode 1 was only active for c.25 minutes.

1188. Split injection was only activated for a second for PCDD4. For PCDD4 the less than 1 second activations of split mode were due to what the Claimants term "the kill switch". which applied whenever the vehicle left the EUDC torque/speed zone. PCD says that the absence of further operation of the split mode was because the way the vehicles were driven did not trigger the parameters listed above. Mr King and Mr Savage gave the example of doing the on-road testing in reverse, such that it started on the motorway, as an example of where split injection would have activated.

1189. The Claimants refute the suggestion that reversing the order of the cycles within the test could have made a difference. Mode 1 was not active at all in six out of the seven road tests for PCDC6 (see the table above). Half of them were hot start tests in which the filtered engine coolant temperature was above 75°C from the outset, causing Mode 2 to apply throughout the test. In the cold start tests, the ambient temperature at start-up was outside the NEDC temperature zone, causing the vehicle to start in Mode 3 then move into Mode 2 once the filtered coolant temperature was reached. Accordingly, the Claimants say that those tests could have been driven in any order, with any type of driving, and the split mode could not have activated due to the mode priorities.

1190. In the JTP non-NEDC dynamometer tests (WLTP and US06 tests), the behaviour of the two vehicles was different (the activation periods are summarised below):

i) For PCDD4, there was activation between 1, 2, 8 and 11 seconds due to the "kill switch" that applied whenever the EUDC torque/speed zone was exited;

ii) For PCDC6, there were longer periods (101, 110, and 87 seconds) because, the "kill switch" for this CSV only applies within a narrower band of engine speeds, and because unlike the road tests, the dynamometer tests were all cold start tests conducted at an air temperature of 23°C which meant that, as set out in the table below, for most of the time the vehicles were in Mode 1, so split mode was accessible.

	Test length	Mode 1 selected (except when in split mode)?
PCDC6 US06 on 30 April 2025	600s	Yes (mode 1 throughout)
PCDC6 US06 on 30 April 2025	600s	Yes (mode 1 throughout)
PCDC6 WLTC on 1 May 2025	1,800s	Yes (mode 1 until the last c.200s)
PCDC6 WLTP on 22 April 2025	1,800s	Yes (mode 1 until the last c.100s)
PCDC6 WLTP on 7 May 2025	1,800s	Yes (mode 1 until the last c.200s)

1191. One of the main reasons for this very limited deployment of split mode is the existence of the timer, the agreed effect of which is to limit the maximum duration of split injection per journey to 110s for PCDC6 and 120s for PCDD4. This timer does not expire in the NEDC (in the JTP, split mode was active for 105s in the baseline NEDC for PCDC6 and 88s for PCDD4) but the presence of the timer means that should the conditions for split injection occur on the road over a longer period, or on multiple occasions in the course of a longer drive, split mode would not activate.

1192. In the FFDs this timer was labelled as an "*energy threshold*" or "*accumulated thermal energy*" measured in joules. Mr Lesueur did not address this parameter in his witness statement, presumably because the Claimants had not found or pleaded it when his witness statement was served. Mr Savage in his written evidence sought to suggest that this timer was measuring energy, but orally conceded it was simply a timer insofar as it counted at a constant increment. Mr Lesueur also accepted it was simply a timer, albeit his evidence was that it <u>should</u> have been designed as an "*energy threshold*".

1193. For PCDD4, there was also what the Claimants have referred to as a "kill switch", the effect of which is to speed up the timer to 327.67 times the normal rate such that split injection instantaneously and permanently deactivates whenever the vehicle moves outside the torque and speed zone in which split mode is active (i.e. the torque and speed

zone of the part of the EUDC in which split mode was designed to activate). The effect of this aspect of the calibration is agreed.

1194. PCDC6 also has a similar switch, albeit one that only applies between engine speeds of 3000rpm and 4000rpm. At 3,200rpm, it counts at a rate of 40 units per second, and at that rate of counting split mode would permanently deactivate the device within a couple of seconds. In addition to that "kill switch", in PCDC6, split mode is only accessible out of Mode 1, which means that unless the vehicle is driven in NEDC conditions (ambient temperature between 17/19°C and 30/32°C, filtered coolant temperature below 75°C, and altitude below c.700m) split mode cannot activate at all, even if all 7 of the parameters for the activation of split injection are satisfied and the timer and "kill switch" have not been exhausted.

1195. The net result of the calibrations is that the split injection mode works very predominantly in the NEDC and very little outside it, because it is parameterised in a way which coincides with the test.

1196. In the first place, the seven parameters that enable split mode to trigger mirror a specific section of the EUDC phase of the NEDC test. Thus in the JTP, and in internal PCD tests, split mode was indeed triggered in different vehicles at almost precisely the same point on the NEDC. The seven parameters are not so precise that they are never met simultaneously outside the NEDC. They were met often in motorway driving during road tests in the JTP, and many such requests were made in each of the tests shown.

1197. However the additional parameters which disable the activation of split mode in particular conditions (the timer, the "kill switch", and, for PCDC6 only, the mode prioritisation) have the result of limiting the application of split mode outside the test. The Claimants submit that I should conclude that the additional parameters have been devised by reference to the NEDC test, e.g. the timer is just slightly longer than the period for which split injection is required to be active in the key EUDC phase of the test, and the "kill switch" deactivates split mode outside the torque/speed window of the EUDC.

1198. PCD says each of the limiting factors has a perfectly good justification not related to the NEDC test – largely to do with concerns about wear and tear on the fuel injectors in the context of this being a new technology for the vehicles and durability being untested.

1199. So far as this is concerned the correlation is certainly striking. Despite multiple split mode activation requests in the road tests, the longest period split mode was in fact in operation for in a road test was 1 second, as can be seen below. The plot in the middle shows the many split mode activation requests. The plot at the top shows that split mode was only activated once, for 1 second.

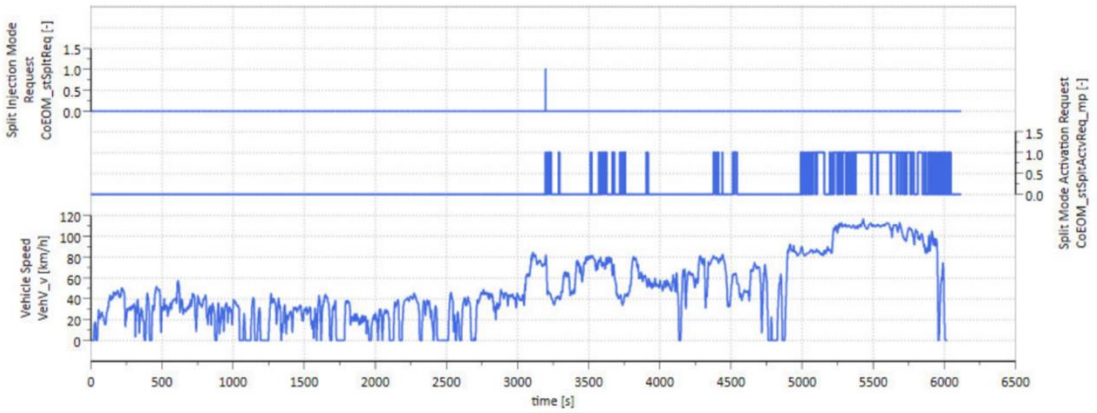


Figure 41: Split injection mode activation across an RDE, PCD-D4 RDE5

1200. Similarly, if back-to-back EUDCs are driven within the NEDC air temperature range, split mode is only active in the first EUDC, because the timer expires or the kill switch causes split mode to deactivate. But in every NEDC test, split mode would be active in the EUDC.

1201. There is no direct evidence that the split injection device was designed specifically to target the NEDC; but at the same time the way in which it works is such that it provides optimum benefits in the NEDC.

1202. The simple fact of the minimal triggering in the on road tests is not enough. However it is actually strengthened by the fact upon which PCD relied that multiple activation requests for split injection that were made on the road, given that (i) there are devices in operation to prevent this happening and (ii) those devices themselves have a fairly obvious relevance to the NEDC. It is artificial to consider only the criteria which enable the mode to trigger, and ignore those that cause it to disable in NDC outside the test.

1203. Without the fact of split mode activating (for PCDC6, split mode activated for a maximum of 110 seconds; for PCDD4 split mode only activated for very short periods (a maximum of 11 seconds) due to the "kill switch") in dynamometer testing in the JTP outside the NEDC test the case for tailoring to NEDC would be very strong. However it would appear that the reason for this is that the dynamometer tests were all carried out at 23°C, so Mode 1 applied throughout the US06 tests, and for all but the last 200 seconds of the WLTP tests, at which point the filtered coolant temperature exceeded 75°C, and Mode 2 was selected. In other words, the tests took place within the air and coolant temperature range of the NEDC. Again therefore the evidence deployed against cycle recognition appears rather to support it than otherwise.

1204. On the evidence therefore there appear to be two purposes involved in split mode. The first is the agreed primary purpose of noise and soot control. That relates to the existence and outlines of the device. But there appears also to be a further purpose which drives the precise calibration and the cluster of parameters and devices which are involved: that is NEDC recognition.

1205. I therefore conclude that while there are two purposes one significant purpose of teh split injection device was the recognise the NEDC test, and operate differentially in that test to outside of the test. It follows that split injection is a CRDD. If CRDD is not the appropriate approach, a DD. I do not consider that the very minimal engagement outside

the NEDC test (referred to above) is sufficient to amount to part of the template for the Claimants' template analysis.

The contemporaneous documents on RIE

1206. In those circumstances I need place no reliance on the contemporaneous documents, although the Claimants' case is that contemporaneous documents provide a form of "smoking gun" so far as regards split mode and cohere with a culture of being relaxed about approaches which were (as one PCD author said in an entirely different context) "*not in the spirit of the law*".

1207. They pointed in particular to the following documents:

i) 5 July 2005 document referred to above (which for the reasons given should not form part of any conclusion);

ii) An analysis of internal testing in March 2009, in which PCD recognised that one of the reasons NOx was much higher in an NEDC carried out at -7°C compared with one at 20°C was "*the absence of any split over the EUDC*" and attributed the change from split mode to warm mode (Mode 2) to cause a "*sudden rise in NOx*", in the EUDC phase, or in French: "*envolée de NOx"***;**

iii) When transitioning to RDE, a Selectivity document of late 2015 showed that issues were analysed by reference to "*detection risk*" and the "*image impact on the group*" and selected for change where the composite risks were too great;

iv) PCD has never volunteered its existence to any regulator, and no regulator has identified it independently. Apparently the first occasion on which split mode was explained by PCD to an external audience was in Mr Lesueur's evidence in the Dutch proceedings in 2025, after Dr Heitz had uncovered the existence of split mode through software analysis. That statement provided an incomplete account of its operation because it did not deal with the "timer/kill switch".

1208. None of this appears to pertain directly to this issue and does not therefore advance matters.

<u>RIE</u>

1209. In the circumstances this issue only arises contingently but on that contingency takes on great importance. Interestingly the starting point is that it is agreed that the evidence shows that split injection either does or can have some effect on NOx emissions, and the dispute is all about how much and how significant that amount is.

1210. The Claimants submit that the result is split injection causes NOx emissions to decrease to a similar degree in each NEDC in which it is active. PCD's case is that:

i) The split injection device does not cause more than statistically insignificant RIE;

ii) In any event the vehicles would have passed the NEDC even if split injection were not active.

1211. PCD's pleaded case (contrary to the Claimants' submissions) remains essentially the same as the case advanced in closing. It is that:

i) Split injection had "*no or no material effect on NOx emissions*";

ii) "*This technique was used by PCD to reduce both engine noise and soot emissions. It is not used to reduce NOx emissions*".

1212. The more extreme aspect (no effect) was overtaken by Mr Lesueur's witness statement which accepted that split injection reduces NOx, saying that injecting fuel in a single shot "*leads to NOx emissions production"* and that splitting the injection "*results in low NOx emissions*" and is used to "*control emissions*". That was also in line with the evidence of Mr Lesueur and Mr King in cross-examination. It is also consistent with the evidence of Professor Martinez Botas evidence in the PCD JS that split injection "*can also influence the formation of NOx depending on the specific split injection strategy*".

1213. The test data shows the following:

i) In the NEDC + 10% tests (an NEDC test driven 10% more quickly than a standard test) meant that split injection was only triggered for 1 second for PCDD4 due to the "kill switch". It was triggered for 92 seconds for PCDC6, but at different points in the test to the point at which it is triggered in a standard NEDC;

ii) Mr King contended that by splicing data from different tests together, he could produce a "no split mode" test to use as a comparator. The results of that analysis show a mean increase in NOx for PCDD4 of 14.3%;

iii) The results for PCDD6 were contentious:

a) The initial results of that analysis for PCDC6 show a mean increase of 4.7%. That figure was adopted and used by PCD;

b) However, Mr King (PCD's expert) said it was better to adjust those initial results to exclude one of the baseline tests for PCDC6 because it was an outlier. The outlier result produced a conformity factor of 1.46. Indeed, when the result was obtained in the JTP, PCD wrote an email complaining that it should be repeated because "*the behaviour of the driver was too severe*";

c) With that outlier test excluded, the results are a mean increase of 8.8%;

d) As to this it appears that the Claimants are right that the more robust approach is to exclude this test.

iv) The NEDC + 3 x EUDC test (a standard NEDC test followed by 3 repeats of the EUDC phase) produced a result whereby split mode was active in the EUDC in the standard NEDC as normal, but inactive in the subsequent EUDCs due to the expiry of the timer and/or the mode prioritisation. 1 of the 6 repeat EUDCs was performed in Mode 1 and logically provides a clean comparison between an EUDC in which split mode was active as it would be in any baseline test and otherwise in Mode 1, and an EUDC driven immediately afterwards within the same drive cycle, in which

the vehicle was in Mode 1 throughout. The increase in NOx emissions (across the whole NEDC) with the EUDC with no split mode was 9%;

v) PCD's open ECU data based on unagreed testing undertaken internally and unilaterally by PCD on a vehicle which Mr Lesueur says is "*of the same variant as PCDD4*", comparing the average of the three NEDC tests with split mode active with the one test with split mode deactivated shows a percentage increase of 9%. With Mr King's "splicing", his conclusion was that the percentage change in NOx emissions without split injection was 12.2%, rather than 9%.

1214. While the mechanical engineering experts agreed that within the JTP there is no test data which compares (i) emissions with split injection activated and (ii) emissions with split injection deactivated, at the same conditions those tests were capable of giving some insight. Pulling together the results from the various tests, the pattern is clear and consistent: split injection causes NOx emissions to decrease to a similar degree in each NEDC in which it is active:

Type of test	PCDD4	PCDC6
JTP NEDC + 10%	14.3%	8.8% (excluding outlier)
JTP NEDC + 3 x EUDC		9%
PCD internal open ECU (same variant as PCDD4)	12.2%	

1215. PCD maintains that these variations are not sufficient to conclude that there has been a RIE and not material on the ground of test-to-test variability.

1216. PCD's test-to-test variability case only properly emerged in PCD's oral opening. PCD contends that because it is permissible in type approval testing for one of the three NEDCs from which the average is taken to exceed the Emissions Limit by not more than 10%, an RIE of less than 10% is immaterial.

1217. As already discussed above, there is no blanket materiality threshold, although variability and similar issues must be weighed in the balance. Here:

i) The overall results conform to theoretical expectation. Every available set of test data analysed by the experts shows that split mode causes NOx emissions to go down when it is active and to go up when it is inactive in an NEDC test, and to a similar extent;

ii) The 40% increase in NOx identified by a simple comparison of the with and without split EUDCs is of an order which strongly suggests that it is not attributable to test-to-test variability applying PCD's 10% threshold;

iii) Mr King's analysis took steps to eliminate the effect of test-to-test variability. His evidence was that one way of avoiding the effect of test-to-test variation was the splicing method that he applied to the NEDC + 10% and open ECU test data: "*there's quite a bit of test−to−test variation and it's very easy for the effect of one thing to potentially be lost in the effect of another. So this is a very robust way of making sure that the true effect of something is isolated*";

iv) The RIE in relation to PCDD4 exceeds 10% (14.3% or 12.2% depending on which testing data is used) and there is demonstrably an RIE in relation to PCDD4;

v) The RIE in relation to PCDC6 is around 9%. There can be no test-to-test variability in relation to the 9% difference found in the NEDC + 3 x EUDC result because that difference is from EUDCs in the same test. As such, none of the variables that Mr King identified as being relevant to test-to-test variability arise: "*driver behaviour, variation/repeatability of the emissions measurement devices, small differences in boundary conditions*";

vi) Professor Martinez-Botas maintained that a difference of 8.5% was a material difference. None of the experts have said that this is an immaterial reduction. Mr King accepted that the reduction brought about by split injection was significant: "it is a significant NOx reduction" and "*when considering the type I test ... it is significant*";

vii) The fact that the percentage change between the NEDC + 10% and the EUDC + 3 x EUDC is nearly identical suggests that there is no significant test-to-test variability in relation to PCDC6 specifically.

1218. Overall therefore the evidence suggests that the cause of the difference in NOx emissions with and without split is due to the absence of split injection, rather than due to test-to-test variability.

1219. The evidence is that split mode reduces NOx by around 9%-14% in the NEDC for the CSVs. That is a large reduction, not least because split mode is only active less than 10% of the test in each case. It is clearly designed to effect measurable and material optimisation on the NEDC.

Testing out

1220. The case as to Testing Out is seductive. However it is, for reasons already canvassed, wrong.

1221. Were it not wrong there is an issue as to whether it is even possible to ascertain a meaningful answer to the testing out question. The Claimants say that it is not possible to obtain an NEDC test result in which split mode is not active without open ECU testing. For this reason, the JTP test results relied upon by Professor Martinez-Botas and Mr King involve splicing test data together, and the NEDC + 10% testing Mr King prefers involves alteration of the driving pattern in the test in such a way that introduces variables other than the DD. That does not prevent it being used as test data which shows the general effect of split injection on NOx emissions, but it does seriously limit its weight as data which answers the binary "pass or fail" test of "testing out".

1222. I accept that a legal test that relies upon open ECU testing is unfair to the Claimants. The Claimants cannot conduct their own open ECU testing to corroborate PCD's data and had no knowledge that the testing was going to be carried out and so had no involvement.

1223. When the comparison is between the baseline spliced "no split mode" tests, and the "with split mode" test, the difference was, in Mr King's words, between being: *"just on the legal limit" (NOx CF 1) to above the legal limit when the split injection strategy was deactivated*". Were "testing out" permissible this would not discharge the evidential burden which at this point must fall upon PCD.

Conclusion on RIE

1224. It is not in dispute that split injection can reduce NOx. The test data shows that it does in fact reduce NOx. Split mode clearly has the potential to bring very significant NOx reduction on the road, but it almost never does so because it is prevented from activating due to the various facets of the DD. There is an RIE.

Article 5(2) issues

1225. PCD's case on this is not consistent with the conclusions to which I have come on the law.

Atmospheric Pressure

1226. This alleged DD can be briefly dealt with in the light of earlier findings. The MAFSP was increased (which the Claimants say produces an RIE) from above around 700m in both CSVs. The MAFSP is increased and the EGR is ramped-out until the point at which the EGR is shut off completely as set out in the table below:

	PCDC6	PCDD4
Corrections start	930hPa (c.700m)	925hPa (c.760m)
Ramping	Nearly linear	Stepped, with a sudden correction of 0 to 0.8 at 900hPa (c.900m)
EGR disabled	840hPa (c.1,500m)	875hPa (c.1,200m)

1227. It follows that MAFSP adjustments for altitude only commence at (the lowest) 700m. In the light of the decision at paragraph 465 above there is no DD and the question of RIE does not arise.

1228. If, contrary to this, a consideration of RIE became necessary one would be looking at (*ex hypothesi*) an adjustment somewhere between 700m and a level of higher altitude which is still less than the level where adjustment becomes justifiable. Any RIE up to a certain level beyond this is likely to be *de minimis*. There is some evidence that there would be a failure at 940m because when PCD vehicles sold in Argentina with a DV6D engine

(the same as the engine in PCDD4) calibrated to a Euro 5 European standard were tested in Betim, Brazil at 940m altitude, they failed to meet the Emissions Limits for NOx.

Temperature window (EGR IAT)

1229. There is no dispute about how the device works. A correction is applied to the MAFSP from 5°C IAT by which the EGR rate is ramped down until -10°C IAT, at which point the correction factor reaches 1, and the experts agree it is reasonable to assume the EGR is disabled. Those parameters are the same as the DD in Ford's FC1, which also had a DV6 engine. The ramp down from 5°C to -10°C is similar for the two CSVs.

1230. The issues here are therefore not dissimilar to those which arise for Ford. The window operates on the basis of IAT not AAT. Therefore the 5°C inception point will often and on the balance of the evidence including the Claimants' concession that "*generally speaking AAT = IAT -5°C*" does fall outside the range I have determined for NDC. Certainly there is no evidence that it is triggered within NDC. Accordingly the allegation fails at this stage.

1231. This is also in line with the expert evidence: Mr King's evidence was that PCD's low temperature corrections to its MAFSP maps were justified and that was not challenged by Professor Martinez-Botas, who indeed agreed that that derating at IAT of 5ºC and below was "*intentional and necessary*".

1232. As for RIE the results from the JTP do not justify a conclusion that on the balance of probabilities there was an RIE. On the contrary the CFs achieved in the JTP (and regulatory investigations) suggest that there is no RIE, given the expected increase in NOx at low temperatures in any event.

Torque/Speed

1233. The Claimants' case is that PCD increased the MAFSP and thereby derated the EGR by reference to torque and speed, with significant derating of the EGR from torques of around 60Nm (PCDC6) or 80Nm (PCDD4) and engine speeds of 2,300rpm for both vehicles and that this amounted to a PDD.

1234. The starting point requires a step back. As outlined above in some vehicles the EGR rate is set by reference to MAF. A vehicle has a MAF sensor which monitors the MAF (incoming fresh air). The ECU determines the desired MAFSP and aims to achieve this value as closely as possible by modulating the EGR valve position. A lower MAFSP results in the EGR rate being increased; a higher MASFP results in the EGR rate being decreased. Modulation of the MASFP is a perfectly normal function of a diesel engine - if an engine is running at high torques and speeds, it is inevitable that EGR would have to be reduced to permit sufficient oxygen to enter the combustion chamber to ensure stable combustion. Some levels of increase in MFSP are therefore necessary, or sensible and cannot be complained of. Like many of the other points in issue it is a question of degree and judgment.

1235. The Claimants say that in the PCDs CSVs the line is drawn wrongly. Their case is that the MASFP is significantly lower, which causes the EGR rate to be significantly higher, at the low torques (of below around 60 NM (PCDC6) or 80Nm (PCDD4)) and below engine speeds of 2,300rpm (for both) (§105 Heitz PCD 1). This is the case across

Nominal 1, 2 and 3, but the effect is greater in Nominal 1 which is the only mode which applies during an NEDC. During the NEDC, torques are generally low and engine speeds never (in the case of PCDC6) or almost never (in the case of PCDD4) exceed 2,300rpm.

1236. After some lack of clarity in opening, it is now agreed that the modulations of MAFSP were as alleged by the Claimants. The question is whether they were a DD. In opening it was submitted that there were disputes as to whether:

    i) The torque boundaries (around 60Nm for PCDC6 and 80Nm for PCDD4) are NDC: PCD says that torque up to 160Nm is NDC for PCDD4 (no equivalent positive case is made for PCDC6);

    ii) The rpm boundary of 2,300rpm was NDC. PCD says that engine speed of up to 2,200rpm are NDC.

1237. In closing the issues were perhaps less well defined, with focus having moved to the boundaries of NDC more generally and with PCD focussing on the point that conditions encountered in NEDC must be taken to be within NDC, and that these thresholds were within the NEDC while the Claimants focussed on the PCD calibration philosophy by reference to a document of May 2009 which refers to combustion modes which are not part of this trial (by reason of the ruling which I made shortly before trial).

1238. The essential points in my judgment are as follows.

1239. There is nothing wrong with modulating MAFSP for torque and speed: it is common ground that adjustment of the MAFSP against torque and engine speed is an inherent feature of combustion in a diesel engine. Adjustment of the MAFSP is taking place continually in order to prevent sub-optimal combustion and an attendant sub-optimal control of emissions as well as risk of overheating which is *"real, well-documented and can have serious implications for engine performance, emissions compliance and safety."*

1240. This is not a case of a sharp or sudden modification akin to a switch – and this is tacitly accepted by the Claimants who do not suggest that this is a CRDD. Mr Savage's MAFSP maps shows that MAFSP is gradually changed as load increases.

1241. There was some argument about the analysis performed by Mr King based on Mr Savage's maps, but whether one looks at the original maps or Mr King's iteration it is possible to discern that there is no sharp, sudden, dramatic or even significant change in MAFSP above 50 or 60 Nm.

1242. As regards the allegation that the MAFSP was inappropriately increased at engine speeds of over 2,300rpm, the experts agreed the following in relation to engine speed: "*there is relatively little adjustment of EGR rates with engine speed*."

1243. Overall the expert evidence did not support any case that the calibrations here were wrong (outside the range open to a reasonable calibrator, given that there was agreement that such points involve judgment).

1244. Further the Claimants face another hurdle in that the criticised torques and speeds were used in the NEDC Test – and so would either come within Article 5(2)(c) or would not be available to the Claimants on their template argument. This can be seen from the

following illustration where it can be seen that PCDC6 exhibited torques of up to 179Nm with 24.3% of the NEDC test at above 60Nm.

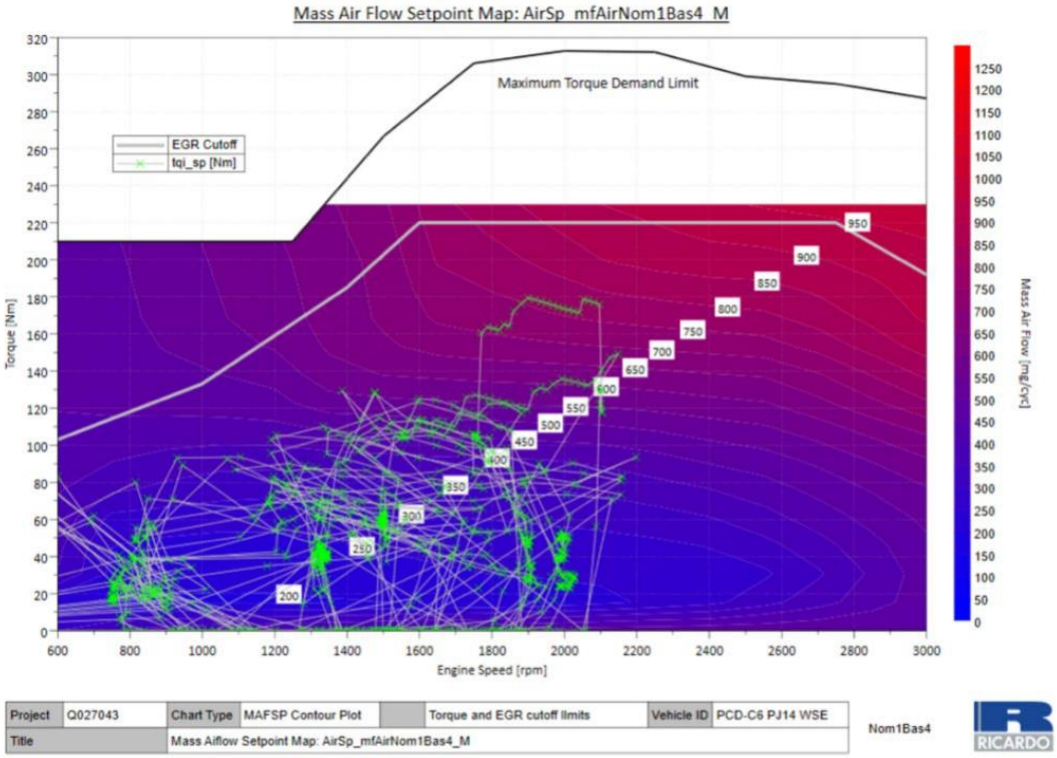


Figure 7: MAFSP Contour plot for Nom1Bas4 PCD-C6, with the speed and torque profile from an NEDC overlayed. Speed/torque profile is from PCD-C6 test DT2 (cold-start NEDC at 23°C).

1245. For PCDC4 similarly some 29.5% of the duration of the NEDC test is spent at torques above 50Nm, 22% of the time is spent above 60Nm, and 14.3% of the time is spent above 80Nm.

1246. Finally even if a DD were made out, it is impossible to conclude that there was an RIE: Professor Martinez-Botas agreed that at higher engine torques and engine speeds, NOx emissions will naturally be higher than those generated during the NEDC test. Professor Martinez-Botas did not attempt a mathematical or scientific analysis to assess the effect of higher loads and speeds on NOx emissions compared to those produced in the NEDC test. In other words, there was no analysis of the increase in NOx which would arise naturally as engine speed and torque increases.

1247. This conclusion is reinforced by evidence from the on road testing: For both PCDC4 and PCDC6 engine speeds were above 2300rpm on average of approximately 2% across all RDE tests These percentages would be even smaller if torques below 60Nm (PCD-D4) and below 50Nm (PCD-C6) were excluded.

Euro 6 Combustion modes

1248. The "bridge" from the Euro 5 combustion modes described earlier to the actual issue here is that the Claimants say that combined effect of LowCO_2 mode applying in nearly all non-NEDC driving and the AdBlue throttling alleged in relation to the SCR was that the vehicles were very polluting, with conformity factors of up to 12 times the Emissions Limits, outside the NEDC test. This was seen as an "image risk" for PCD and led PCD

to change the parameters for LowNOx mode by the Kaizen NOx update which was installed on both the Euro 6 CSVs at manufacture.

The alleged Kaizen Nox Combustion Mode PDD

1249. Both parties' firmware experts agree that:

i) The selection of EOM1 vs EOM2 is dependent upon a number of factors, including in particular, ambient air temperature, ambient air pressure and vehicle speed. Specifically, for what is known as "Urban Conditions" all of the following three conditions need to be satisfied:

a) AAT between 7/9°C and 30/32°C;

b) Air pressure above 930/940hPa; and

c) Vehicle speed below 60/62km/h.

ii) There are two "routes" to activate EOM1 (via satisfaction of the "Urban Conditions" or via satisfaction of the "Second Conditions"); and

iii) If EOM1 is not activated, EOM2 is activated.

1250. The Claimants' case on this alleged PDD moved considerably over the course of trial. In summary:

i) The case was originally pleaded as a CRDD. That allegation was abandoned in written opening. At the same time the Claimants also abandoned any PDD allegation in relation to the Warm-Up Drive Type;

ii) In oral opening the Claimants accepted that Warm-Up was not a defeat device for the purposes of this NOx litigation (although they would and do call it a cheat on other fronts);

iii) There had also been a case advanced in relation to the Second Conditions under which the Low NOx mode can operate; that too was not pursued. So the live portion of the trial started with this DD complaint being limited to the temperature, altitude and speed parameters of the "Urban Conditions";

iv) By the time of closing (despite a long written closing section ranging over the history of the technology) there was a further narrowing in that no complaint was ultimately pursued on the 60 kph speed parameter for transition from EOM1 to EOM2.

1251. Accordingly, the only remaining disputes are as to the Urban Conditions' temperature and altitude parameters. To some extent there is therefore an overlap with the temperature and altitude conditions already considered. It will be apparent that, even on the basis of the conclusions I have reached (as opposed to the wider case pursued by the Claimants), PCD potentially has an issue here, at least as regards temperature - albeit that that case is fairly limited (3-7°C) – particularly given that all three conditions have to be engaged at once.

1252. PCD suggested that on the Claimants' "template" approach, advocated in closing, it becomes hard to see how the calibration offends because on the evidence EOM2 is used in the NEDC test. However the actual usage does not help PCD. It is as set out below.

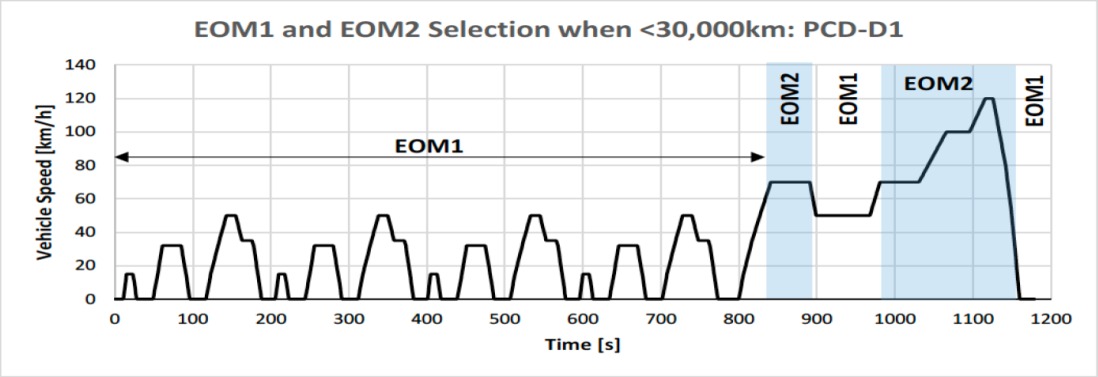


Figure 48: EOM1 and EOM2 selection across a standard Type 1 NEDC test for a vehicle type of PCD-D1 when the vehicle mileage is below 30,000km

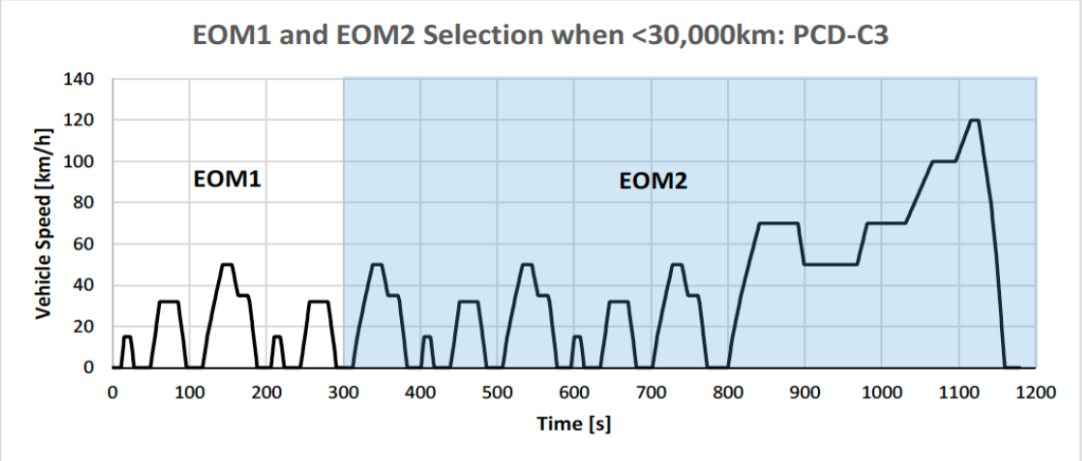


Figure 46: EOM1 and EOM2 selection across a standard Type 1 NEDC test for a vehicle type of PCD-C3 when the vehicle mileage is below 30,000km

1253. Thus for PCDD1 that usage is triggered by the 60kph condition and not the temperature condition which is really the controversial element of the device. For PCDC3 the engagement appears much more complete, but it is again as a result of other conditions – the Second Conditions, which are not part of this trial.

1254. For both, therefore, the trigger for the mode appearing in NEDC is not the trigger of which complaint is made. It follows that there is indeed a potential DD (subject to RIE) which relates to the thermal window element of the switch between combustion modes.

RIE

1255. Accordingly the bulk of the fight between the parties has been on the evidence of RIE. On this the Claimants depended heavily on the inference to be drawn from the change modes (generally Low NOx will be lower NOx than Low CO_2) and the change in MAFSP rates: Mr Savage's evidence was that the MAFSP is generally lower in LowNOx Mode and that "*higher MafSP setting (EOM2) would typically result in low EGR flows and higher NOx emissions*" and Dr Heitz's plots show that the EGR valve is open to a greater degree in LowNOx mode than LowCO_2 mode.

1256. Against this PCD points out that there is no evidence at all geared to the specific narrow conditions of which complaint is now made (or the even narrower conditions which I have found actually bite). As they correctly say, Mr Savage's evidence is directed to EGR changes at large. There is no evidence as to differences in MAF setpoints in the relevant conditions even at the desktop level. The only tests performed which come close to the relevant conditions are the -3°C tests and it is common ground between the engineering experts that the -3°C test cannot be used to compare the effectiveness of the ECS in EOM2 vs EOM1. Any RIE test at this level would have to take into account the expected higher NOx at lower temperatures. There is therefore a lack of a relevant comparator to be identified on the basis of which the Claimants could demonstrate that the use of EOM2 rather than EOM1 at temperatures below 7°C reduces the effectiveness of the ECS. Indeed there were some PCD internal test results, combined with test results from the Commission Royal, KBA and DfT and the certification results which seem to show stable NOx emissions above and below 7°C, notwithstanding the use of EOM2 below 7°C.

1257. Dealing with the RIE case "at large" as previously put, PCD posit the absence of any evidence of any significant or material difference. They rely on the fact that Mr King's analysis shows no material difference in MAF in NEDC conditions. That evidence relates to an analysis of the differences in the MAFSP at speeds above 60km/h during the back-to-back 23°C NEDC and concluded that "*the MAF when the Firmware was operating in EOM2 during the second (hot) EUDC was very similar to the MAF when the Firmware was operating in EOM1 during the first EUDC*". Mr King concluded that it was not therefore correct to state that the EGR rate of EOM1 was higher than EOM2 and Professor Martinez-Botas agreed with Mr King's analysis and concluded that the MAFSPs were "very similar" for EOM1 and EOM2 in these tests. He also opined that the "best comparison" of EOM1 v EOM2 from the JTP was the back-to-back 23°C NEDC. Similar results were gained in internal PCD testing on a Peugeot 208 1.6l vehicle, which has the same engine as PCDC3 and PCDD1, in which EOM2 is forced above 60/62km/h by calibration. This showed (a) that NOx emissions are very similar whether EOM1 or EOM2 is selected at speeds above 60/62km/h (EOM1 – 64 mg/km, EOM2 – 65 mg/km) and (b) the vehicle passes the NEDC test with EOM2 forced above 60/62km/h.

1258. PCD also point out that PCDC3 operated in EOM2 for 75% of the NEDC Type 1 approval test. Despite this, a vehicle of its variant still comfortably passed that test, with a NOx level on the Certificate of Conformity of 37.6 mg/km. This adds to the evidence that EOM2 does not result in any relevant RIE.

1259. To the extent that it were to become relevant (given the findings above regarding NDC) I note that Professor Martinez-Botas accepted that there is no evidence of any RIE in his expert reports at any altitude above sea level, let alone 700m.

<u>Article 5(2)</u>

1260. Were this to arise PCD says that the use of the EOM2 fuel injection settings at temperatures below 7°C, above 32°C and at altitudes above 700m was necessary to ensure proper combustion and/or was justified for reasons of safety and/or to avoid damage to the engine. In that respect, as stated above, the retarded injection timing in EOM1 can lead to engine instability at low ambient temperatures and at low ambient pressure and causes increases in exhaust temperatures. For reasons of safety and/or to

avoid damage to the engine, it was therefore necessary to use EOM2 (rather than EOM1) at temperatures below 7°C and above 32°C and at altitudes above approx. 700m.

1261. In the light of the findings on NDC this barely arises. To the extent it does I am not persuaded that the risk (of deposits causing the EGR valve to be stuck open or closed and incomplete or suboptimal combustion) demonstrated justified the limits set – as opposed to the limits of NDC. Although the limit was plainly the result of a good deal of research and was a not set at an unreasonable point, that is not the question at the point of justification.

1262. For none of the aspects of the update which were in issue is there sufficient evidence of risk to justify what would otherwise be a PDD.

PCD's Euro 6 SCR

1263. As with all manufacturers relying on SCR as their sole aftertreatment technology, PCD had difficulties in the NEDC because for most of the test the SCR catalyst had not warmed up and had not become fully effective; this meant both greater difficulty in meeting the NEDC limits and the necessity for a greater use of EGR (with the consequent fuel/CO_2 penalty that entailed).

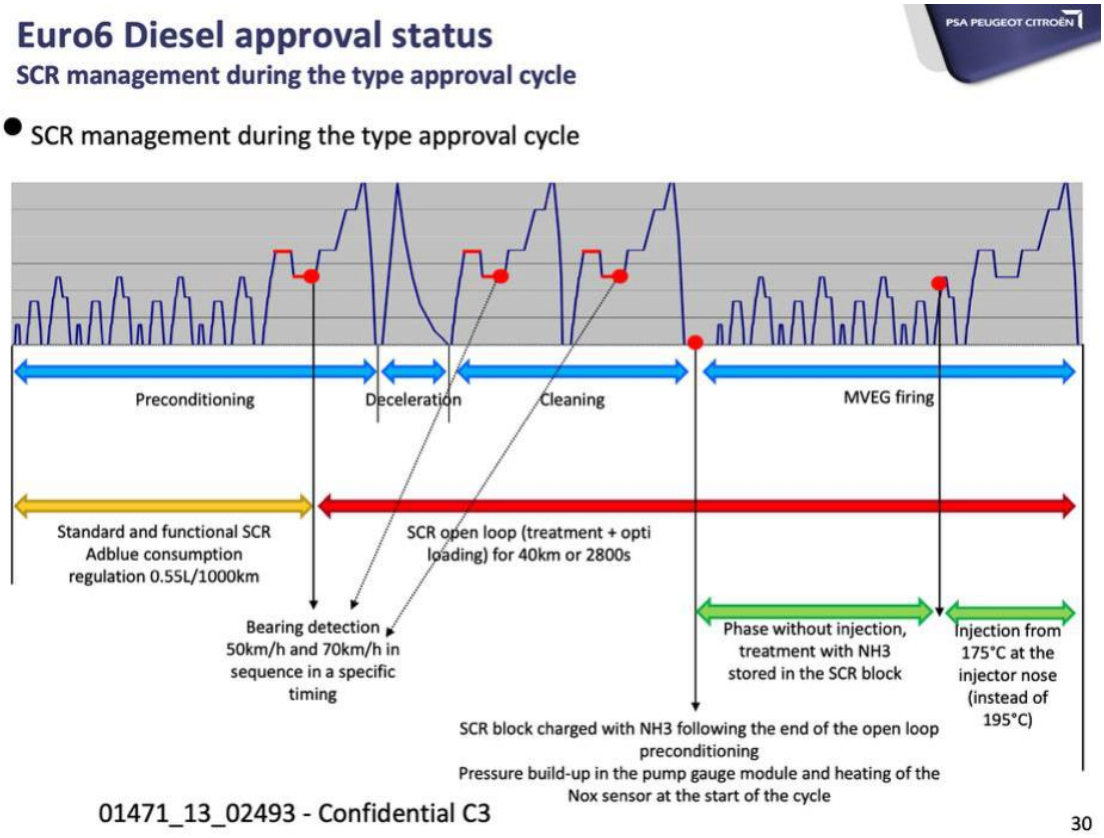
1264. PCD designed its SCR system to operate in one of two modes:

i) "Consumption Control Mode" ("CC Mode", "CCM" sometimes referred to in the litigation as "SCR Mode 2"): This was often called "*regul conso*" or "RC" and sometimes "*boucle fermée*" in French in PCD's documents. CC Mode will usually be activated if AdBlue consumption since engine start exceeds 0.55litres/1,000km. It regulates AdBlue consumption from engine start to not exceed that average;

ii) "Non-Controlled Consumption Mode" ("NCC Mode" "NCCM", sometimes referred to in the litigation as "SCR Mode 1"). It was referred to in PCD's own documents as "BO" – denoting "*boucle ouvert*" or "*open circuit*". NCCM operates whenever CCM is not activated, so will generally operate when AdBlue consumption since engine start is less than 0.55l/1,000km or for diagnostics;

iii) Late in the day the Claimants have sought to split out the NCCM mode into two sub-modes. The Claimants now accept that NCCM can operate both in test and on the road. The Claimants describe the version that applies in the test (when triggered by cycle recognition) as "NCCM(Test)" and the version that applies outside the NEDC as "NCCM(Road)". As Mr Cutress KC for PCD pointed out in closing, this was not a pleaded case.

1265. The operation in the NEDC is visually described thus:



1266. This has led to a degree of complication/confusion as to what the case is as to CRDD.

i) The case was pleaded on the basis of an CCM/NCCM division: firmware detects the cycle and operates in NCCM in cycle and in CCM otherwise. The CRDD was said to be CCM. It was this case on which the experts originally opined;

ii) The case was then opened – following PCD pointing out that NCCM also operated on the road - on the basis of the sub-modes; specifically that it was NCCM (submodes) which were the true issue, with the case being put thus:

a) Once triggered by the cycle recognition, NCCM (Test) persists until the vehicle has been driven for 40km or 2,800 seconds in one uninterrupted driving cycle. It survives the engine being switched off, but the timer resets, such that when the vehicle restarts it will operate in NCCM(Test) until that distance or time is passed in a subsequent drive;

b) Second, it enables AdBlue injection to start at a lower temperature of 165°C or 175°C, whereas outside the NEDC, dosing starts at 195°C; and

c) Third, it has a higher dosing limit;

d) The result was that NCCM (Test) operates throughout preconditioning and the NEDC itself (i.e. the whole TA procedure) due to the timer; the SCR catalyst is pre-loaded with ammonia, meaning that the SCR can immediately start reducing NOx as soon as any temperature permits the conversion reaction between NOx and ammonia during UDC; that further

AdBlue injection can start earlier, at lower temperatures; and a higher dosing limit applies such that meaningful variable dosing, responsive to the varying levels of engine-out NOx produced, is possible during the NEDC test.

iii) The case closed on the following basis: the Claimants say that

a) CCM is a PDD – it operates to ensure that in all non-NEDC driving, the effectiveness of the SCR is capped to maintain an average dosing rate of 0,55l/1,000km. It is prevented from operating when the NEDC test is detected.

b) In addition:

> "The NCCM/CCM mode switch is a PDD, and (so far as is material) a CRDD(DM), as NCCM(Test) is designed as a special 'test only' mode to optimise NCCM for the test, in order to pass the test or improve results under it both at type approval and during in service conformity testing"

.

1267. This has the slightly surprising consequence that on the basis of the closing the Claimants say that all the SCR modes are defeat devices.

1268. As for the shift in case, PCD said the Claimants were not entitled to pursue it, absent an amendment which was never sought. Mr de la Mare argued in closing that the Claimants were perfectly entitled to pursue their developed case. I am not entirely in sympathy with this; PCD having pointed to NCCM operating in real life, the Claimants were entitled (absent an amended pleading):

i) To run a case that CCM was still a CRDD because it did not operate in the test and was switched to when it was detected that the vehicle was out of test. That is not actually how it was put by the Claimants;

ii) To say that the argument that NCCM (as encountered on the road) is essentially a different thing to the NCCM they are talking about (as encountered in Test), such that there are effectively three modes, of which only two are relevant for the purposes of this argument. This was effectively Mr de la Mare's submission: the Claimants were perfectly entitled to say "*no, the mode that you have pleaded as operating on the test is not the same as the mode that operates in the real world*."

1269. However, to the extent that what is being said is that NCCM (Road) should not have been used in real life and the NCCM (Test) should have been used instead, that was not the pleaded case, or the development of the pleaded case. That falls outside of the case which the Claimants had permission to run in this trial. This judgment therefore confines itself to considering the case as it relates to the NCCM (Test) and CCM switch.

1270. There is a certain amount of agreement about this mode. It is agreed that NCCM (Test) was designed to operate in the NEDC. For PCD that is because NCC Mode enables the

injection of AdBlue without the consumption regulation that can be imposed by CC Mode. This enables mandatory diagnosis of the SCR system, which is necessary to satisfy regulatory OBD requirements.

1271. It is agreed that a suite of different behaviours occur in NCCM (Test) which are only triggered in the NEDC by cycle recognition of the EUDC and the activation of the cycle recognition (or "NORIA") flag, specifically:

i) CCM is prohibited so there are no limits on AdBlue consumption;

ii) A different dosing map is applied to that operative in CCM (and also in NCCM(Road)), by which the maximum dosing limit applies at all times that AdBlue injection is permitted;

iii) AdBlue dosing is permitted at a lower SCR injector temperature of 165°C or 175°C rather than 195°C, to which end the AdBlue pumps are pressurised from ignition rather than when the SCR is warm;

iv) The NOx sensor is pre-heated earlier;

v) These behaviours persist until the cycle recognition (aka NORIA) flag is cleared which cannot happen until the vehicle is driven for 2,800 seconds or 40km in one continuous drive. So, if the vehicle is keyed off before the NORIA flag has expired, the process will start again from the beginning.

1272. The differences between NCCM (Test) and NCCM (Road) are that in the latter dosing limits are graduated by reference primarily to exhaust gas mass flow, with dosing starting only when the injector sensor reaches 195°C, the pumps will activate later, and a differential NOx sensor heating strategy applies. All of this delays both the initial onset and initial intensity of dosing by comparison with NCCM (Test).

1273. There is a great deal more complicated material as to the operation of the modes, further rendered obscure by the late shift in the case.

Cycle recognition

1274. It seems hard to resist the conclusion that CCM mode involved cycle recognition. PCD's argument that average AdBlue consumption is well below the level necessary to trigger CC Mode is circular – if there is a CRD or a CRDD the trigger for the switch would be expected not to be reached. The evidence of the DT2-Rpt test where CCM was not triggered even though adjustments were made to some of the trigger conditions does not engage with this.

1275. The argument here is more about (i) whether the reason for the design of CCM/NCCM is nefarious (i.e. to lessen NOx in test) and (ii) whether the use of NCCM (in some form) outside of the test means that this is not to be regarded as a test cycle recognition device, or (in the contingent analysis) it is a template case.

1276. On the former points there is relevant background. As PCD explained they were early adopters of SCR, which has since become the go-to technology. At Euro 5 they had no history of working with the technology and there were issues such as reliability of parts and the risk of ammonia slip to work into the equation. There were also constraints:

mandatory diagnosis of the SCR system was necessary to satisfy regulatory OBD requirements and in practical terms required to be performed on the SCR system during a standard Type I / NEDC tests at homologation.

1277. Finally, there was the need for regard to refill intervals; at this stage it was clear that manufacturers did not expect customers to accept or comply with a requirement to top up AdBlue themselves and there was no refill infrastructure in place. It followed that at this stage it made a lot of sense to calibrate dosing to service intervals.

1278. The clear evidence was that the SCR strategy flowed from the following considerations:

i) PCD first defined how much AdBlue was needed to depollute the heaviest car in the fleet. That was calculated at 0.55-litres per 1,000 kilometres (corresponding to 288 mg/km of NOx emissions treated);

ii) PCD allowed for an extra injection of AdBlue for diagnosis purposes. That was calculated to increase consumption to up to 0.75-litre per 1,000-kilometre;

iii) The refilling of the AdBlue tank was aligned with the maintenance interval used on PCD Euro 6b diesel engines and the tank size was then decided upon to accommodate this. In this way, in the ordinary course, customers could have their AdBlue tank refilled at the same time as their vehicle was being serviced.

1279. Professor Martinez-Botas did not take issue with this approach agreeing with the following passage from Mr Chappelle's statement:

> "At the time of Euro 6b, the use of SCR in passenger vehicles was in its infancy and the AdBlue distribution network was not widely available. Further, certain of PCD's Euro 6b vehicles (namely existing and end of life cars) had to be refilled via a pipe in the boot since it had not been possible to adapt the body of these cars in such a way as to allow them to be refilled from a refilling pipe on the side of the vehicle. This was not straightforward for customers to do themselves. In order to deal with these logistical issues, we proposed to align the refilling of the AdBlue tank with the maintenance interval used on PCD diesel Euro 6b diesel engines. In this way, customers could have their AdBlue tank refilled at the same time as their vehicle was being serviced."

1280. The evidence suggests that NCCM is the default setting: the way the software works is that NCC Mode will be activated unless the conditions for activation of CC Mode are satisfied. It is agreed that those conditions are:

i) CC Mode was active at the last engine stop (but this condition is only valid for 600s after dosing has started, in order to prevent CC Mode being active for the whole trip); or

ii) AdBlue consumption since engine start is greater than 0.55l/1,000km AND the driven distance since engine start is greater than 0.2km; or

iii) AdBlue consumption since engine start is greater than 0.55l/1,000km AND the diagnostic function has completed.

1281. NCCM will be active if:

i) It was active at the last engine stop and will then continue to be active for as long as AdBlue consumption remains below 0.55l/1,000km;

ii) If, after engine start, there is no activation request for consumption control (i.e. average AdBlue consumption since engine start is less than 0.55l/1,000km) and the NH3 loading setpoint correction is >=1;

iii) If SCR diagnostic conditions are reached and if average AdBlue consumption is below the threshold of 0.66l/1,000 km for all previous trips;

iv) If adaptation (scatter mode) conditions are reached. These take place every 2,500km and for 20km or 60km. and are used to check the proper operation of the system;

v) CAF is set to 1, which disables the NOx sensor dew point requirements and permits the NOx sensor to be heated to enable it to reach a minimum temperature to operate.

1282. From this one can see that there are a fairly complex range of things being considered. The obvious hallmarks of a CRDD are not present. While the Claimants mocked the argument by reference to diagnostics, it is plain that diagnostics had to be considered, and the relevance of that factor is confirmed by the way that the testing played out:

i) The JTP test results show that no diagnostic takes place in half the tests when the CAF is not activated. In all seven of the NEDC or NEDC−like tests where the CAF was activated a diagnostic took place;

ii) The fact that the NOx sensor (which is only used for diagnostics) is heated below its dewpoint temperature when the CAF is activated, despite the agreed risk of damage in those circumstances

1283. Secondly, not only is there no evidence of comparative assessment of NOx performance between the two modes taking place in advance (as one would expect for a CRDD), the JTP results, discussed below, do not demonstrate any very marked difference in NOx effectiveness between the two modes.

1284. I conclude therefore that there is no CRDD. This is one of those cases where on the surface the arrangement looks very dubious, but a more thorough consideration of all the evidence dispels concerns.

1285. As for the first contingent (template) approach, the fact that NCCM is engaged frequently (25% of the time) outside of the NEDC means that unless the Claimants unpleaded case as to the two sub-modes of NCCM were made out this would fall within the template approach and would not be a PDD. As this was an unpleaded case not properly before the experts I do not propose to consider it in detail. However it appears that the Claimants would have difficulty in establishing that the supposed two sub-modes are truly distinct given that the PCD Selectivity Document notes that the mass of NH3 injected is "virtually the same, or even greater" when the CAF is off (in NCCM (Road)).

RIE

1286. At the centre of the dispute on this issue is the question of whether CCM causes a RIE. Here one needs to focus on NOx figures; or more accurately the correct approach here to assessing RIE. The Claimants say that this must be done by comparing the dosing strategy with and without the DD to assess whether the DD settings cause an RIE, i.e. an increase in tailpipe NOx, when compared with the non-DD settings. They say that on this basis:

i) The effectiveness of the system is necessarily dramatically reduced when CCM applies;

ii) What was commonly seen in the JTP once CCM is triggered was a period of no dosing, leading to full depletion of the catalyst and a collapse in consumption, followed (once average consumption has fallen below 0.55l) by a glidepath of fixed dosing at 0.55l, even where the conditions (say rural or motorway driving on the RDE) were highly productive of NOx and would lead to far higher dosing under NCCM. This leaves the SCR not only itself in a state of reduced effectiveness but unable to respond to and compensate for any increase in engine out NOx emissions, most notably during the 60kph speed deactivation of LowNOx mode implemented by the Kaizen NOx update;

iii) PCD's case that there is no RIE in CCM is inconsistent with PCD's own contemporaneous assessment and testing; the JTP; and its own case as to the rationale for NCCM(Test). It works only if, quite implausibly, "effectiveness" under Art 3(10) is decoupled from system efficiency, via the Absolute NOx Conversion Argument. The Claimants say that RIE is the admitted design purpose of CCM;

iv) NCCM(Road) also causes a RIE when it applies instead of NCCM(Test), primarily by virtue of the high limit map that applies only on NCC(Test) and the lower temperature at which injection is permitted; and this is seen in the JTP.

1287. On PCD's contemporaneous documents the Claimants say that these show that CCM was a deliberate design choice to reduce the consumption implied by operating in NCCM outside the test.

i) A 2006 document described '*maximum efficiency*" in NCCM vs "*reduced off-cycle efficiency*" in CCM;

ii) A document authored by Clément Grise describes "*maximum NOx conversion efficiency*" in NCCM vs CCM which "*will degrade the effectiveness of the system*";

iii) PCD internal testing carried out in 2008 illustrates the huge drop off in NOx conversion "efficiency" when CCM is active across different drive cycles, compared with when it is not active and vehicle is in NCCM. Even with a higher per journey throttle of 0.75l/1,000 km the difference in efficiency ranges from 26% to 42% as an average across the whole drive cycle, depending on the relative load demands of the cycle in question;

iv) PCD internal testing carried out in November 2013 shows the efficiency achieved in an NEDC test carried out in NCCM ("*maximum depollution*"), even allowing for a cold start leading to substantial periods where the SCR cannot dose or cannot even treat from stored NH3, is 70% versus 59% for CCM ("*nominal depollution*"),

v) PCD's own illustration (produced on 23 September 2015) showed how AdBlue dosing was intended to work in a vehicle driven on the road with CCM active: "*…the vehicle will be at maximum efficiency for the time it takes to complete the Diagnostics … Then it regulates to obtain an average Adblue fuel consumption of 0.54L/1000km*".

1288. PCD, aligning itself with other SCR manufacturers, contends that the correct way of assessing RIE in this context is via the Absolute NOx approach or failing that the Testing Out approach: the absolute amount of NOx emissions converted by an SCR system per km on average (i.e. Absolute NOx Conversion) when a vehicle is driven on the road outside NEDC test conditions is no lower than the Absolute NOx Conversion when the vehicle is driven in an NEDC test in compliance with the Emissions Limits. If this approach is correct the Claimants accept that "*on the evidence of the JTP, RIE would not be established*."

1289. Further PCD says that the JTP shows average conversion efficiency of around 60% in CC Mode in PCD's (aged) Euro 6b CSVs, that even with CC Mode applying, and despite their age and mileage, the Euro 6b PCD CSVs achieved an average CF during the RDE tests of around 3. PCD also says that the "contemporaneous" documents usually relate to different engines or are misinterpreted.

1290. Overall what this area shows clearly is (again) the difficulties of assessing NOx reduction effectiveness in the SCR technology. The Claimants' case is essentially a desktop one. In terms of logic it looks compelling – and the PCD documentation (for all that much of this does not deal with these engines) seems to show that the PCD expectation would be some reduction in effectiveness.

1291. However as already explained, making a conclusion of RIE on a desktop basis without supporting test material is not a robust approach, particularly in circumstances where testing in this case has in some other respects shown that the expected does not happen, in the context of considering a single mechanism in the abstract and then testing that mechanism in real life together with all the other processes going on in the engine.

1292. That however brings one back to the inadequacies of the processes for testing SCR effectiveness. As already indicated, I do not accept that the Absolute NOx approach is an acceptable/robust approach. The better approach is the Percentage NOx approach – but this is one with which PCD did not engage (understandably, because it formed no part of the pleaded case, and effectively came to the fore as a result of the arguments as to the problems with other approaches).

1293. I have also indicated that I do not consider that Testing Out is an answer. However it is notable that PCD's SCR CSVs appear either to pass the NEDC test or to come close to passing it on this approach.

i) As regards PCDC3

a) the test undertaken on the JTP produced a conformity factor of 0.95 and the experts agreed that "*PCDC3 passes the NEDC test with SCR Mode 2 [i.e. CC Mode] activation*". Professor Martinez-Botas confirmed that in his oral evidence;

b) The other tests for that vehicle were entirely consistent with that result. Professor Martinez-Botas agreed that it made no material difference to the NOx tailpipe emissions whether the vehicle was in CC Mode or NCC Mode;

c) The Claimants' attempts to challenge these results via the impact of EOM2 above 60kph is not evidenced or supported by the Claimant's expert.

ii) As regards PCDD1 the picture is more complicated as the result on CCM was 1.45, compared to 1.36, 0.92, 1.14, 1.15 and (Horiba MIRA) 1.7. The evidence here suggests some, but not very significant RIE, particularly if the Horiba MIRA result has to be regarded as a credible part of the dataset (and on this the experts seemed to say (delphically) that they could not say that it should be ignored). The Claimants' attempts to cherry pick the best results cannot be accepted as a proper approach, particularly given the factors impacting the quality of data to which reference has already been made.

1294. This indicates that contrary to expectation, any reduction in effectiveness for the PCD SCR vehicles is fairly marginal.

THE RENAULT CSVS

1295. There are three Renault CSVs RC2, RC3 and RD2. RC2 received a software update in service which extended the operating range of the EGR and frequency and efficiency of LNT purging. RC3 and RD2 have not received an update. The vehicles are as follows:

	Euro standard	**Model**	**Engine**	**Type**	**Year of manufacture**	**ECS technologies**
RC3	5	Trafic	R9M	Light Commercial Vehicle (Van)	2016	HP & LP EGR
RC2	6b	Renault Captur	K9K	Passenger Car	2016	HP & LP EGR, LNT
RD2	6b	Renault Captur	K9K	Passenger Car	2017	HP & LP EGR, LNT

1296. While it is not the "senior" ALGLO, Renault has a status as something of an *eminence grise.* Renault is a manufacturer of long standing – continuously in business since it was founded by Louis Renault in France in 1899. Renault's diesel vehicles essentially promoted by a favourable tax regime became more popular in the 2000s. This led Renault to focus increasingly on diesel vehicles and engines; and its engines have been supplied to other manufacturers, including Nissan and Mercedes. Renault sits in one GLO with Nissan, since Renault supplied Nissan's diesel engines. All the Nissan CSVs have Renault K9K engines. But as a result of collaboration with other manufacturers, particularly Mercedes, the Renault engine is frequently in focus in this litigation.

1297. Renault has served statements from and called three witnesses: Denis Reverseau, Matthias Bouchez, and Antoine Pineau, who were involved in the design and manufacture of Renault's Euro 5 and 6 engines. Their evidence was broadly consistent with the expert mechanical witnesses.

1298. Mr Reverseau has worked for Renault for 30 years. He is a mechanical engineer who at the time material to these claims worked on developing and validating the ECS within Renault vehicles, including the CSVs.

1299. Mr Bouchez has worked at Renault for 24 years as a project manager overseeing the development of diesel engines, including defining all aspects of the depollution system. While he was not part of the NOx monitoring (updates) committee ("NMC"), as a member of the RAP Committee (which oversaw decisions on projects in relation to software and tuning), he met weekly with that committee to receive updates and provide feedback.

1300. Mr Pineau has worked at Renault for 27 years and in 2005 became the head of the tuning department. The Claimants complain about the fact that Renault did not call any member

of the NMC, Alain Petit (Homologation), Alain Raposo, or Philippe Pelletier (powertrain engineer). They were said to be relevant because all of them were involved with regulatory discussions post-Dieselgate, and could speak to the operating strategies in the CSVs; Mr Pelletier could speak to the "*LNT operating conditions and philosophy*", and Mr Petit to the EGR at low temperatures.

1301. The witnesses who were called gave evidence on the complexity of calibrations, the history over time of the calibrations and the problems which Renault had encountered and the various safety issues. They were fair and reasonable witnesses who were endeavouring to assist the court.

1302. The Claimants' expert in the Renault case, Professor Tunestål was a noticeably reasonable expert, giving evidence in a balanced and measured way, conceding ground where appropriate and acknowledging the scope for calibrator judgment in a number of respects.

1303. The specific background to the Renault CSVs so far as EGR is concerned is that they use a dual-loop HP EGR and LP EGR system. The two loops cannot operate simultaneously. It is agreed by the experts that LP EGR is more effective at reducing NOx emissions than HP EGR, save that in cold conditions LP EGR may have an influence on combustion stability and lead to elevated CO_2, HC and CO emissions.

1304. The Claimants contend that the deliberate combined effect of the EGR PDDs, and the common temperature-based switch ("Hot/Cold Switch") was to create a Hot (or "Depollution") Mode, which was carefully calibrated by the cumulative application of the above DDs, to provide low emissions during the NEDC test. In Hot Mode, the NEDC Zone was protected, NOx emissions reduction was highly effective, and the Emissions Limits are consistently met. However, outside the NEDC Zone, even in Hot Mode, NOx emissions reduction was much less effective.

1305. In Cold Mode (initially operative in both Euro 5 and Euro 6 below 17°C), NOx emissions were at most a secondary consideration, and subject only to Renault's Off-Cycle guideline implemented for Renault Brand Image purposes. The effect is that NOx emissions significantly increase in Cold Mode, which can be active in very mild temperatures (in pre-Update RC2, up to 16.9°C ambient temperature). The Claimants say that Renault took a tripartite approach to EGR in Cold Mode of: (i) more frequent EGR wholesale deactivation; (ii) a lower EGR rate (when operative); and (iii) using HP EGR even in those higher temperatures in which LP EGR was and is more effective.

1306. The broad thrust of the Claimants' case against Renault was that: (i) Renault tuned and optimised its ECS strategies to the NEDC test, (ii) off-cycle Renault prioritised fuel consumption and had far less regard for reducing NOx emissions, (iii) Renault implemented software updates quickly in 2016 following the announcement of RDE monitoring tests for Type Approval and – with more speed – post the Volkswagen scandal, (iv) the updates demonstrate the original calibrations were never required as a matter of safety, and (v) the updates themselves were not calibrated to the safety limits of the engine.

1307. Like Ford and Nissan, an LNT DD is alleged. The EGR DDs alleged in the Renault case were:

i) a Thermal Window ("Thermal Window DD") (broken down into a HP/LP EGR switch and upper-end-cut=off);

ii) a Mass Air Flow Based DD ("MAFSP/EGR Rate DD");

iii) a Torque Cut-Off DD ("Torque Cut-Off DD");

iv) a Low Atmospheric Pressure Based Device ("Atmospheric Pressure DD"); and

v) a device to delay the start of the LP EGR, based on ECT ("Delayed Start DD").

Thermal Window Threshold and cut off (IAT and AAT EGR)

1308. Although this was never alleged as a CRDD, Renault otherwise at first blush appears to be in the most exposed position of any of the Defendants when it comes to this type of alleged PDD. That is because the Hot/Cold Switch (or "Thermal Window Threshold") in each CSV is:

i) 17°C IAT (RC3),

ii) 17°C AAT (RC2 pre-Update),

iii) 8°C AAT (RC2 post-Update), and 3°C AAT (RD2).

The RC2 pre-update and RC3 figures are therefore squarely within the NDC range on any analysis.

1309. Further as to those devices, this is well above the types of "lower temperature" where, as Professor Plá and others explained, the impact of the type of EGR on improvements in NOx emissions is reduced. This may be a factor (as with Ford) at a 5°C trigger point; it is not when one is in the teens. This is a distinction that is relevant to the post update figures. There one is in the territory where lower temperature may well start to impact on NOx. This was spoken to by Professor Tunestål who accepted that a test performed at 10°C represents a "fairly major change of temperature" compared with Type 1 test conditions and that this demonstrated how lower temperatures cause increased emissions.

1310. Further, RC2 deactivated EGR entirely at 36/38°C IAT (pre-Update) and 43/45°C IAT post-Update. This cut-off (the "Upper EGR Temperature Cut Off") formed part of RC2's Thermal Window.

1311. The Claimants' case is that the effect of the Thermal Window is that in NDC– i.e. below 17°C IAT, and 17°C, 8°C, and 3°C AAT, and above 36/38°C and 43/45°C IAT – the effectiveness of the entire ECS was for Euro 5 vehicles (RC3) significantly reduced, and NOx emissions increased.

<u>Thermal Window Threshold</u>

1312. There are however complications. Renault did not derate EGR at the lower end; rather they switched from LP to HP EGR. While the question as to RIE remains, it is a slightly more complicated question than the linear deratings seen in other manufacturers.

1313. Nonetheless there is evidence which supports a conclusion of an RIE. While Renault points to the absence of precise testing (with the nearest being at 10°C – a significant disparity) and the potential effects of the LNT in RC2 and RD2 in confusing the issue on tailpipe NOx, I conclude that the evidence which there is tilts in favour of a conclusion that there was an RIE. There certainly is evidence that this would be expected to lead to less effective NOx reduction: the Renault JS, §12.5: "*If conditions allow the use of LP EGR and HP EGR, LP EGR will always be more effective at reducing NOx production*". The Nissan JS was to similar effect: "*The combustion chamber temperature when in HP EGR mode will (all other things being equal) be higher and more NOx will be formed*".

1314. The likelihood of higher NOx after the switch was also accepted by M Bouchez. Renault also disclosed a document which dealt with KBA testing in 2016. That testing produced a result of 1,276 mg/km (CF 16) on a NEDC below 17°C – some way from an arguably acceptable CF. Renault's own conclusion was that this was:

> "Cumulation of 3 effects: 1/Climate settings (<17°C therefore HP EGR less efficient than LP EGR and framed at 500 mg/km in development…3/HP EGR cut-off very likely because the depolluted area covers the NEDC + hysteresis pair. It is estimated that the mass effect causes N/TQIs to pass above the EGR cut-off"

1315. As for the effect of LNT this should reduce rather than increase emissions, so if it has an effect it should be in Renault's favour. While it might be said that LNT works worse outside the NEDC, due to purges being less efficient and purging only once the LNT is fuller or even overflowing, it still works to purge to some extent. And while the Claimants' reliance on what was done later is often oversold (the fact that something could have been done later does not mean that it could have been done earlier), here they make the entirely valid point that in terms of approach what Renault did do to reduce emissions in this area was to reduce the temperature at which the switch kicked in. That is consistent with the evidence above. The Renault case on this otherwise depends upon the Holistic Approach, dealt with above.

1316. I therefore conclude that:

1317. R C2 pre-update, and RC3were DDs;

i) RD2 post update was not a DD;

ii) RC2 post update triggers on a window which is sufficiently close to the lower boundary of NDC, and sufficiently within the area where temperature itself will affect NOx production that I am not satisfied on the balance of probabilities that there would be an RIE.

1318. So far as justification is concerned for the RC pre-update vehicles is concerned there is no evidence of significant safety risks leading to this switch. This does appear to be a case of Renault calibrating at least by reference to the NEDC test without sufficient regard for the balancing factors. The disclosure suggests that the thinking was that by using 17°C IAT, Renault could always ensure that Hot Mode (encompassing both the Warm Up Maps and Hot Maps) would always be on during the NEDC test. Renault could in theory have calibrated to 18°C, but if the sensors were even slightly inaccurate, this

could risk the vehicle starting in the Cold Mode. 17°C allows a one degree margin for error, as Professor Tunestål confirmed.

Upper cut-off

1319. As for the upper boundary it is agreed that RC2 cut EGR above 36/38°C IAT, and 43/45°C IAT (post-update). The dispute between the parties is whether that modulation amounts to a DD and/or was justified.

1320. The Claimants' case is that given that 36°C IAT could easily be reached at an ambient temperature of 30°C, it is beyond any realistic argument that the cut-off applies in NDC. Renault defends the cut off as a reasonable engineering decision at the time given known safety risks such as loss of power due to the oxygen deficit caused by reduced air density at high temperatures being exacerbated by the effects of EGR and increased emissions of HC, CO and PM and the risks which flow from that including to the DPF and DOC, and sudden turbocharger failure. Renault also says that RC2 and RC3 cannot properly be compared as they are very different vehicles with different components.

1321. Given the conclusion reached on NDC boundaries no defeat device is established in relation to the upper-end-cut-off. This is on the borders of NDC, but it is on balance just the right side for Renault. Further evidence on RIE in this regard is lacking. Had justification arisen, given the higher boundaries applied elsewhere (at the same time) and the relatively distantly related (incidentology) and abstract nature of the justification evidence a justification defence would not succeed for RC2, though for the higher threshold at 43/45°C IAT the balance would shift.

Torque Cut-Off Device

1322. In the Renault CSVs, EGR is cut at certain torque levels, which in turn are based on engine speed/gear combinations. The Claimants allege that the cut offs by reference to temperature, gear, and engine speed are a PDD. In practice the effect of this device overlaps with the MAFSP device, as EGR is often cut by both a torque cut and a MAFSP cut off at around the same time.

1323. The Claimants say that the boundary at which this switch-off operated for this switch off is extremely close to the maximum torque seen in the NEDC and this amounts to a "boundary device".

1324. The details of the alleged device are somewhat complicated:

i) The Torque Cut Off Device cuts off EGR above certain torques.

ii) A hysteresis (governing the shut off and return to use of EGR) is then added to the torque value. The hysteresis means that if the map has a torque value of 100 Nm, EGR will cut off at 120 Nm during acceleration (i.e. 100 + 20 Nm).

iii) The Claimants say that the values on the maps, particularly in Hot Mode are too close to NEDC outlines to be anything other than a boundary device:

a) The torques/rpms encountered on the NEDC test fall squarely within the Hot Mode Torque Map Cut-Off Points (i.e. EGR would not be cut off during the test, but would in NDC);

b) This would be 20 Nm (as it is in the CSVs) "*if the mapping is calibrated exactly for the NEDC*";

c) The Hot Mode hysteresis map in the CSVs is described as being "*calibrated according to the emission control requirement often at 10 Nm*".

d) For many earlier Euro 5 models, it appears the calibration was cruder, often being mapped to just 10 Nm above the maximum torque associated with particular engine speed/gear combinations on the NEDC test (with maxima set by gear, using their knowledge of what gears would be in use and when in the NEDC), giving a very fine calibration; thus the Claimants say that;

e) For later Euro 6 models, the NEDC was divided into its two sections (i.e. UDC and EUDC), and the Torque Cut-Off would be 10 Nm higher than the maximum torque experienced in each section. In Cold Mode for the Euro 5 CSVs, EGR is cut at very low torques (i.e. around 110 Nm for RC3, 60/90 Nm for NC1), with the maps appearing "minimally calibrated". In Cold Mode for Euro 6s, the cut-offs occur closer to the NEDC Zone, but still occur at lower torques (and in greater NDC) than in Hot Mode;

1325. The result is said to be that as the NEDC is a low torque/rpm test, in NDC EGR is regularly completely cut off due to higher torques being encountered. For example, in RC2, EGR will be cut (even in Hot Mode) at torques above 155 Nm (gear 3) and above 129 Nm (gear 5). These are said to be torques commonly encountered in those gears.

1326. The Claimants also rely on the argument by reference to updates: that in later models, Renault's mandate was to "remove" the sharp cut-offs in Hot Mode as part of the "EGR zone extension" thereby ensuring that EGR is permitted in a greater range of operation than in RC2/RC3.

1327. The Renault case starts with the sound proposition that modulation to reflect torque and speed is not an optional extra – it is necessary. This was something on which there was thorough agreement by the experts.

1328. The question then becomes whether the approach taken by Renault is wrong, despite the ambit for judgment; and whether the Claimants' suggestion of a boundary device is sustainable.

<u>Boundary device "calibrated to NEDC"</u>

1329. This was not the Claimants' originally pleaded case. It appears to derive from expert evidence, in particular Dr Heitz's graphs and Professor Plá's plots of warm up maps for RC2 which the Claimants say show operating points sitting neatly below cut offs. That was reflected in Professor Plá's written evidence which was that the cut offs appear deliberately calibrated so that they are above operating points on the NEDC.

1330. The Claimants also relied on Renault's own 2008 calibration guide of the Hot Mode Torque Cut Off map as demonstrating that the purpose of the map and its calibrations are linked to the NEDC:

> "cut off the air regulation (EGR + flap) when excessive acceleration is detected. Calibration is based on a compromise between too severe a cutoff

penalizing the depollution cycle and calibration that penalizes driveability by leaving the EGR on acceleration….

"torque mapping beyond which air regulation will be cut off in normal mode. This mapping concerns the engine speed and the gearbox ratio. We use as a value the max. torque associated with the engine speed and the gearbox ratio on which we have EGR on a de-pollution cycle + 10 Nm""

1331. However this is to oversimplify a vastly complex issue. As Mr Myhill pointed out each map contains hundreds of values based on different operating points, and impressionistic interpretation can lead one astray. The calibration guide upon which reliance was placed did not match up with the CSVs which were before the court – which did not apply the hysteresis described.

1332. Professor Tunestål had not performed any analysis of the actual maps himself and Dr Heitz was not qualified to analyse them. Looking at the maps, I conclude that whatever is going on in the torque calibrations it is not a CRDD-type boundary device – not least because it has been demonstrated that the cut-offs did in fact operate during the test. The flip side of the Claimants' case on "almost 100%" is that in fact 3% of the time in the NEDC EGR was non-operational and the vast majority (2.9%) of that figure is due to torque cut offs. Further while it is true that on the road more cut offs are seen, that is hardly surprising.

1333. Further too, Professor Plá's evidence demonstrated that EGR would be available across a large range of engine speeds equivalent, in each gear, to the speeds commonly encountered in those gears. He also demonstrated that EGR was available for the majority of the time in real world driving, including in the post-IPOC tests.

1334. All of this is enough to establish that there is no CRDD/boundary device. But that is made more firm a conclusion when a closer look is had at the analysis which is said to demonstrate that the torque cut-off tracks the torques in the NEDC test with a margin. When looked at more carefully it is possible to see that the torque cutoff line fluctuates independently of the speed line. That is confirmed by analysis from Professor Plá which showed that there was no consistency of margin between the torques experienced in NEDC and the thresholds used in each gear.

1335. Overall this part of the case appears likely to have been the result of a conflation by Professor Tunestål of a few documents taken from Renault's disclosure which he wrongly interpreted in the light of Dr Heitz's maps as suggesting cutoffs at levels of 100 rpm above the maximum engine speed in the NEDC and 10 Nm above the maximum torque in the NEDC. That this is not a correct statement as a matter of generality is now tacitly accepted by the Claimants.

Standard defeat device?

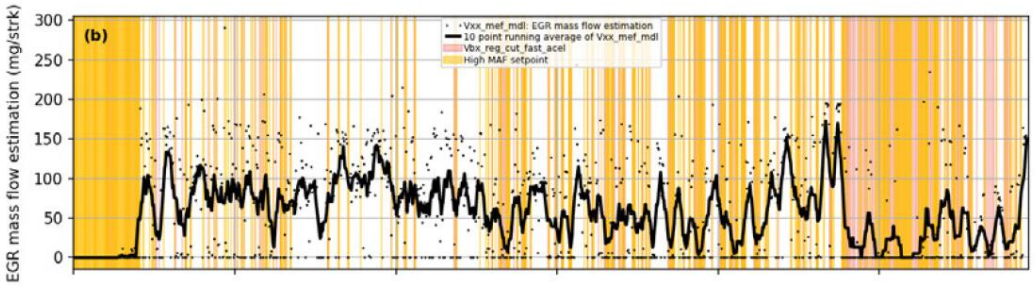
1336. This still leaves the question of whether there was a standard defeat device. Given the nature of the exercise this has to some extent to be done by reference to an evaluation of the decision-making process. Was the result probably wrong because it was not reached robustly?

1337. Here, the Claimants' case is stronger because while the "standard margin" case is not sustainable, there certainly is evidence of Renault calibrating to torque cut offs using test

margins as a benchmark rather than by reference to safety/mechanical justifications. Thus:

> "3.7 Tuning the other cold air EGR HP cut-offs
>
> 3.7.1 Cut-off in TQI
>
> To calibrate the Cmp_egr_hot_tqi_thd_rij label [Cold Mode map], the EGR activation field must be defined based on N and TQI….
>
> The speed/TQI cut-off must be just beyond the operating field on the NEDC cycle in order to maintain customer consumption:
>
> - 100 rpm beyond the Nmax of the NEDC field
>
> - 10 Nm beyond the maximum TQI of the NEDC field
>
> "It will be advisable to separate out the ECE and EUDC sections for the best possible optimization…."
>
> "Cut off the air regulation (EGR + flap) when excessive acceleration is detected.
>
> Calibration is based on a compromise between too severe a cutoff penalizing the depollution cycle and calibration that penalizes driveability by leaving the EGR on acceleration....
>
> ...torque mapping beyond which air regulation will be cut off in normal mode. This mapping concerns the engine speed and the gearbox ratio. We use as a value the max. torque associated with the engine speed and the gearbox ratio on which we have EGR on a de-pollution cycle + 110 Nm"".

1338. That concern is added to when it is borne in mind that there are real oddities. Thus in Cold Mode, at Euro 5 level, there is no evidence of a Torque Cut Off calibrated to any engineering or safety limits. Rather RC3 cut EGR at 110 Nm torque (with 20 Nm hysteresis included). In practical terms this would mean no EGR above torques of 110 – up to 17°C. That is surprising because if it is set that low, one is likely to see EGR cut off if one simply accelerates. The submission was made that it would be inconceivable that one could drive on the motorway at those sorts of speeds without EGR being cut. And this was not simply submission at large. The chart below shows this happening in testing.



1339. This was an allegation with which Renault simply did not engage in Closing Submissions. EGR was on the evidence generally higher in NEDC. Nor was it the case that the tests show comparable EGR rates between NEDC and on road testing. On

Professor Plá's figures, EGR was cut 3.83% of the time in the NEDC, and about a third of the time on the road tests.

1340. As for RIE some, if not striking, RIE is established on the evidence. Professor Plá agreed that if RC3 had been calibrated with fewer cut-offs and more EGR, the NOx figures in the road tests would have been "better". The figures were:

i) In on-road tests conducted at temperatures of between 11 and 16°C, RC3 produced more NOx than in the NEDC test: the CFs are between 3.86 and 5.56. While increased loading is likely to have played a part, the cut offs and downrates will also have contributed. Professor Plá did not seek to suggest otherwise.

ii) In the NEDC test carried out at 10°C, had a CF of 3.9.

1341. There is then the allegation that cut offs were more sudden and sharp in Cold Mode than in Hot Mode – Cold Mode not being used in NEDC. That was an argument which had some attractions until the effect of MAFSP was factored in. As noted elsewhere he MAFSP generally increases as the torque approaches the cutoffs: it is not the case that EGR is maintained at a constant rate and is then suddenly deactivated in certain combinations of temperature, torque and engine speed. Essentially overall MAFSP smooths the approach to cut-off.

1342. I was also not persuaded that there was anything in the broader allegation that the torque and engine speed combinations at which the MAFSP is set to a level which prevents EGR, which they suggest are lower in the cold mode maps and (ii) the use of higher MAFSP values in the cold mode maps than in the hot mode maps. This is because it is common ground, and engineering good sense, that more fresh air (and so less EGR) is required in cold ambient conditions.

Mass Air Flow Based Device

1343. The MAFSP Maps control the mass air flow, and this has an effect on EGR rate. A very high MAFSP will effectively cut off EGR. Certain of these maps are relied on as creating (i) the Thermal Window (Upper EGR Temperature Cut Off) (ii) the Torque Cut Off DD, the (iii) Atmospheric Pressure DD. But it is also alleged that certain other MAFSP maps constitute DDs.

1344. The Claimants allege that:

i) The Cold Mode correction factor maps cutting EGR below 60°C ECT (RC3)/ 20°C ECT (RC2,RD2); and

ii) The MAFSP maps cutting EGR in gears 4 and 5 in RC2 in Warm Up Mode: are both DDs.

1345. The MAFSP calibrations are agreed:

i) Each CSV has three "families" of maps: (a) Cold Mode maps, (b) Warm Up Mode maps and (c) Hot Mode maps.

ii) The Cold Mode maps are used below the minimum temperature at which LP EGR can be used (17°C IAT for RC3, 17°C AAT for RC2 before its update/ 8°C post update, and 3°C AAT for RD2).

iii) Above that threshold, the vehicle uses the Warm Up Mode maps until a particular engine coolant temperature is reached, and thereafter the Hot Mode maps.

iv) In Hot Mode, LP EGR will be used; and in Warm Up Mode and Cold Mode, HP EGR will be used. The EGR rate in the Cold Mode maps is generally lower than in the Warm Up and Hot Mode maps.

v) In the NEDC temperature range, Warm Up Mode is triggered with HP EGR, followed by Hot Mode with LP EGR; but outside it HP EGR alone is triggered (with no EGR <20°C ECT). The MAFSP is generally lower (EGR higher) in Hot Mode than in Cold Mode.

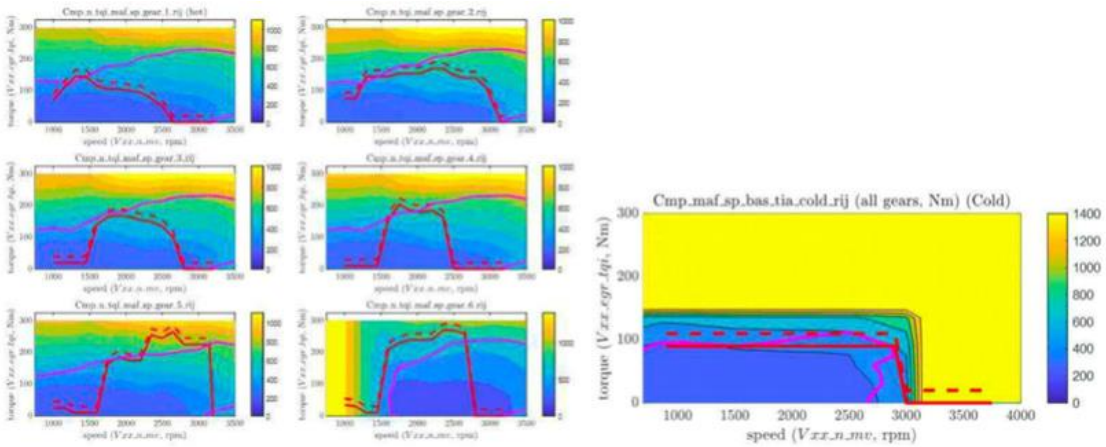
vi) As well as administering a higher EGR rate within the "EGR on" zone, Hot Mode serves to cut-off EGR once the MAFSP exceeds its maximum admissible MAFSP.

1346. Matters are further complicated by the fact that within each family, a different map exists for each gear, particularly in RC2 and RD2.

1347. The Claimants' case is that the switch point between the Hot Mode maps and the Warm Up/Cold Mode maps should have been at a lower temperature essentially for the same reasons as have been relied upon in relation to the thermal window DD. It is said that a consequence of the switch between Hot Mode and Cold Mode being at a higher temperature than it should have been, was that more effective LP EGR was being used less frequently than it should have been, and also that the Cold Mode maps which applied less EGR were being used more frequently than they should have been. Both caused a RIE. There is therefore a connection and overlap between the PDDs.

1348. In addition, as explained further below, the Claimants' case is that there were unjustified cuts and de-rates within the maps. The dispute between the parties is whether those modulations in question amount to a DD and/or were justified.

1349. RC3's Cold and Hot Mode maps are graphed below. The red line on the maps represents the torque cut-off thresholds; the purple line indicates where the MAFSP exceeds the maximum MAF level.:



1350. It can be seen for the description above and these graphs that the DD alleged crosses over significantly with other alleged DDs. I am not persuaded that it has independent life. The MAFSP DD issues are best viewed via Warm Up mode and Correction factor.

Warm Up mode (4th and 5th Gears RC2)

1351. It is agreed that a MAFSP of 1,500 mg/strk is set in gears 4 and 5 in Warm Up Mode (<55°C ECT). The result is that RC2 has no EGR in Warm Up mode or in those gears until the coolant temperature reached the appropriate temperature. The dispute between the parties is whether that modulation amounts to a DD and/or was justified. Renault says that using gears 4 and 5 at less than 55°C is not NDC.

1352. Despite Renault's best efforts this modulation is one which should be regarded as a defeat device.

1353. I accept that it is, as Renault says, a niche modulation and as such it is unlikely to have great significance in the wider picture of the litigation: it applies only in the few minutes at the start of a journey taken in warm air temperatures and only operates until the Coolant Temperature climbs to 57ºC. And it only affects gears 4 and 5, so will only affect vehicle users who travel on fast roads in the first few minutes of their journey. It does not apply when the air temperature is cold or if, in the first few minutes until the coolant temperature rises, the car stays at relatively low speeds. Professor Plá's evidence that the data suggests that this is a very small portion of real world journeys is eminently credible. However it could happen – and will have happened. Someone living in a rural location could easily get to 4th gear within moments of starting a journey. So could someone leaving a motorway-side hotel.

1354. It is also perfectly credible that Renault calibrated in this way for good engineering reasons including the difficulties associated with driving in continuous periods at high gears when the engine is cold, and difficulties which Renault had encountered in maintaining turbocharger boost pressure. However that is not a matter which falls within the Article 5(2) exceptions.

1355. Nor can it be said that this forms part of a template used within the NEDC; indeed it seems possible that this was an oversight in calibration based on the fact that 4th and 5th gear are not used in Warm Up mode in the NEDC, so Renault's calibrators thought there was no need to use EGR in 4th and 5th gear.

1356. It is perhaps worthy of note that this 4th and 5th gear issue appears to have been the subject of criticism of Renault by the DVSA and appears now to have been calibrated out by an update known as PSC 2.

MAFSP Correction Factor

1357. It is agreed that a MAFSP of 1,500 mg/strk is set and EGR is deactivated:

i) In RC2 and RD2, EGR is deactivated at Coolant Temperatures below 20ºC in cold ambient conditions, and reduced in warm ambient conditions.

ii) In RC3, EGR is deactivated at Coolant Temperatures below 60ºC.

The dispute between the parties is whether that modulation amounts to a DD and/or was justified.

1358. While Renault says that this is a sensible way of managing cold weather risks and impacts across a range of emissions and Professor Tunestål confirmed that he did not criticise that calibration, which managed the trade-offs involved in using EGR in a cold engine, the fact is that this is a calibration to switch EGR off, and it is not an entirely niche one, as demonstrated by the testing results. In the 10°C NEDC test, RC3 took over 600 seconds (10 minutes) to reach the threshold. Likewise for RC2, which took 400 seconds (almost 7 minutes), and RD2 took almost 600 seconds on the 0°C NEDC test.

1359. There was no specific disagreement from Renault that switching off EGR at this level will lead to RIE.

1360. Renault's real case here is on Article 5(2). As to this:

i) Although potential risks are identified by Professor Benajes,7 and include wet soot, condensation, lacquering and sooting of the EGR valves such that they stick in position, and the risks associated with increased production of PM, these are not risks (at least to the extent described) which satisfy the Article 5(2)(a) test;

ii) The argument that this is covered by Article 5(2)(b) is unsustainable in the light of the testing results just mentioned;

iii) However on Article 5(2)(c) the evidence suggests that at least in part these modulations will occur in conditions which are experienced on the Type 1 test:

a) In RC2 and RD2, no EGR is used below a coolant temperature of 20ºC, which is a temperature for the start of the test

b) . So that condition will be found in the test, though probably "substantially included" is a reach;

c) In RC3 EGR is not used below a coolant temperature of 60ºC, which is a temperature found for the first few minutes of the test so that condition is found in the test

Delayed Start of LP EGR

1361. This alleged DD relates to ones already described.

i) Above the Thermal Window Thresholds, as has been explained, the CSVs use HP EGR while the engine is warming up (i.e. when ECT is below 74°C for RC3 or 55°C for RC2/RD2) ("Warm Up Mode").

ii) As a result, Warm Up Mode is used in the first ("cold") part of the NEDC test to warm up the DOC. This delays the operation of the LP EGR, as the engine takes longer to warm up, and thus effective NOx emissions reduction.

1362. Again the use of LP EGR before the engine is warm is not criticised by Professor Tunestål. However there is no dispute that LP EGR is more effective at preventing NOx formation than HP EGR.

1363. There is accordingly prima facie a DD in this respect. However here the applies in the NEDC test and would therefore not be a DD on the Claimants "template" analysis. Alternatively it would fall within Article 5(2)(c):

i) In RC2 in warm conditions, HP EGR is used until a coolant temperature of 55 ºC when LP takes over and 55ºC is the temperature experienced during the test;

ii) In RC3 in warm conditions, HP EGR is used until a coolant temperature of 74ºC when LP EGR takes over and that again is a temperature encountered during the test.

Low Atmospheric Pressure Device

1364. The Claimants complain of the fact that RC3 and RC2 wholly deactivate EGR below 890/900 hPa (there is no phased derating, just a wholesale shut off).

1365. Given the conclusions above this is outside of NDC and is therefore not a DD. Had the matter arisen the evidence would not however be sufficient to permit an Article 5(2)(a) defence.

LNT

Introduction

1366. The Renault LNT regeneration strategy was somewhat different to that of Ford – it is focussed on conditions rather than software bits and required steady speed rather than acceleration.

1367. It is common ground that seven conditions must be cumulatively met for the LNT to be regenerated:

	RC2 (Pre-Update)	**RC2 (Post-Update)**	**RD2**
Gear Condition	Vehicle speed = 50-130 kmph Gear = 4 – 6	Vehicle speed = 50 – 200 kmph Gear 4 – 6	Gear = 3 – 6
IAT Condition	Vehicle speed > 50 kmph + IAT ≥ 9°C Vehicle speed = 95-105 kmph + IAT ≥-7°C	Not altered by update	Vehicle speed > 0 kmph + IAT ≥ 3°C Vehicle speed > 95 kmph + IAT ≥ -8°C
Steady Velocity Condition	Filtered velocity does not change more than 0.4 kmph/0.5 seconds	Filtered velocity does not change more than 0.4 kmph/1 second	0– 85 kmph: Filtered velocity does not change more than 0.4 kmph / 1 second > 85 kmph: Filtered velocity does not change more than 0.7 kmph / 1 second

<table>
<tr><th></th><th>RC2 (Pre-Update)</th><th>RC2 (Post-Update)</th><th>RD2</th></tr>
<tr><td>Velocity Dependent Saturation condition –

Low Velocity Configuration</td><td><table><tr><th colspan="2">Low Velocity Configuration</th></tr><tr><td>Vehicle speed</td><td>NOx load</td></tr><tr><td>66-72 kmph</td><td>≥1.4g</td></tr><tr><td>72-97 kmph</td><td>≥2.5g</td></tr><tr><td>50-120 kmph</td><td>≥3g</td></tr><tr><td>>120 kmph</td><td>≥10g</td></tr></table></td><td><table><tr><th colspan="2">Low Velocity Configuration</th></tr><tr><td>Vehicle speed</td><td>NOx load</td></tr><tr><td>50-97 kmph</td><td>≥1.4g</td></tr></table></td><td><table><tr><th colspan="2">Low Velocity Configuration</th></tr><tr><td>Vehicle speed</td><td>NOx load</td></tr><tr><td>0-97 kmph</td><td>≥1.4g</td></tr></table></td></tr>
<tr><td>Velocity Dependent Saturation condition –

High Velocity Configuration</td><td><table><tr><th colspan="2">High Velocity Configuration</th></tr><tr><td>Vehicle speed</td><td>NOx load</td></tr><tr><td>98-102 kmph</td><td>≥ 0.15g</td></tr><tr><td>68-72 kmph</td><td>≥ 0.18g</td></tr><tr><td>102-118 kmph</td><td>≥0.6g</td></tr><tr><td>>120 kmph</td><td>≥2g</td></tr><tr><td>72-97 kmph</td><td>≥ 3g</td></tr><tr><td>≥ 50 kmph</td><td>≥ 3.5g</td></tr></table></td><td>Not altered by update</td><td><table><tr><th colspan="2">High Velocity Configuration</th></tr><tr><td>Vehicle speed</td><td>NOx load</td></tr><tr><td>98-132 kmph</td><td>≥0.15g</td></tr><tr><td>68-72 kmph</td><td>≥0.18g</td></tr><tr><td>68-132 kmph</td><td>≥ 0.6g</td></tr><tr><td>68-133 kmph</td><td>≥ 1g</td></tr><tr><td>≥ 0 kmph</td><td>≥ 1.4g</td></tr></table></td></tr>
<tr><td>Fuel Overconsumption Condition</td><td><table><tr><th>Vehicle speed</th><th>OC value</th></tr><tr><td>>50kmph</td><td>≤0.02 l/100 km</td></tr><tr><td>65-75 kmph</td><td>≤0.1 l/100 km</td></tr><tr><td>75-105 kmph</td><td>≤0.04 l/100 km</td></tr></table></td><td>Not altered by update</td><td><table><tr><th>Vehicle speed</th><th>OC value</th></tr><tr><td>>50kmph</td><td>≤0.02 l/100 km</td></tr><tr><td>65-105 kmph</td><td>≤0.04 l/100 km</td></tr><tr><td>65-75 kmph</td><td>≤0.1 l/100 km</td></tr></table></td></tr>
<tr><td>LNT Temperature Condition</td><td>200-450°C (LNT temperature average)</td><td>Not altered by update</td><td>200-450°C (LNT temperature average)</td></tr>
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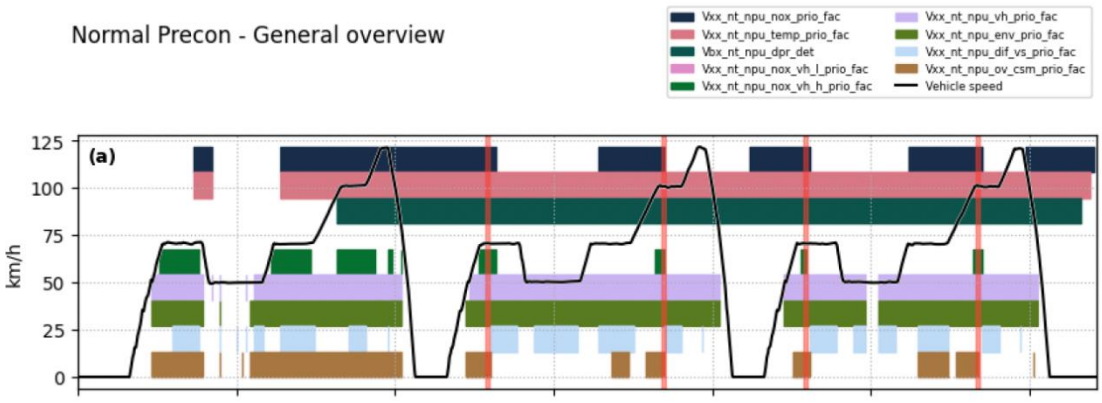
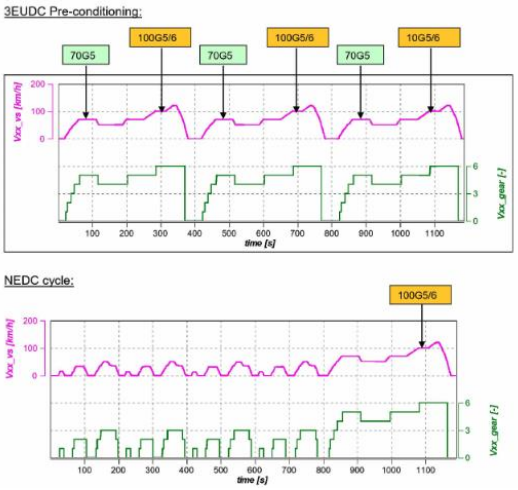
i) A visual representation of this was given by Mr Heitz. Each of the colour lines is one of the seven conditions the Claimants plead in their IPOCs that need to be fulfilled for a purge to happen. The conditions are all fulfilled simultaneously at the beginning of the 70 km/h and 100 k/m steady speed plateau;



ii) This matches the strategy in Renault's calibration guide ("Definition of deNOx engine field") to purge at these points on the cycle.



1368. The Claimants in closing have placed particular emphasis on the fact that these calibrations enabled two purges to take place in the second and third cycles within the preconditioning phase and one purge to take place during the Type 1 test itself.

1369. The Claimants contend that this is a clear test cycle recognition device, which significantly reduced the LNT's ability to reduce NOx in NDC. It operated as follows:

i) It purged twice, and for longer than usual in preconditioning, enabling a clean start for the LNT in the test itself; and it then purged once within the test;

ii) Outside the test, the pre-conditioning purging did not operate and purging was based on the rules operative in the test itself. On this basis the LNT did not regenerate at all below 50 kmph or in gears 1 – 3 (gears 1 – 2 in RD2); and only regenerates in very steady conditions.

1370. To some extent this is a similar allegation to that advanced in Ford – the lack of purges in urban driving conditions and the need for steady conditions; and it is met with similar arguments. The Claimants however contend that the case here is more extreme than the Ford case – the number of conditions which must be met, the precision with which they map onto the EUDC test and the aiming for a very steady state rather than simply a steady state. Further the Claimants make particular complaint of the pre-conditioning settings.

1371. I will deal first with this narrow CRDD case, then the argument that the individual settings amount to a CRDD, and then with the arguments that the individual settings are (if that is wrong) PDDs.

CRDD- preconditioning?

1372. This is about the Velicity Dependent Saturation condition. This condition contains two sets of maps: the High Velocity Configuration map (activated when filtered velocity surpasses 91 or 93 km/h), and the Low Velocity Configuration map. In the High Velocity map, if all other conditions are met, purging can take place without any significant LNT loading between narrow speed wedges of 68-72 km/h and 98-102 km/h (RC2) and 68-72 km/h and 98-132 km (RD2). In the Low Velocity Configuration, far higher NOx loads are required before a purge will be permitted (3g, 1.4g, 2.5g, or 10g, depending on vehicle speed (RC2), and 1.4g for RD2), meaning purges will occur less frequently.

1373. It is now admitted that the real purpose of these calibrations was to ensure purging at the 70 km/h and 100 km/h points of the preconditioning cycle, but only at the 100 km/h step of the NEDC test. As Mr Reverseau explained:

> "The calibration is designed to purge when you need it [on NEDC and in real life]. Then, to ensure the repeatability of the test, we have another calibration designed to be able, on the pre-conditioning, to purge completely the LNT, whatever is the condition of the LNT at beginning. So it is not on the NEDC that we want to reduce the number. On the NEDC -- on the NEDC and on the real life, we want to purge when it is necessary and for the pre-conditioning, we ensure the repeatability."

1374. As explained in an FEV (external calibrators for Renault) guide:

> "The reason for the existence of these two mappings stems from our obligation to perform DeNOx at 70 km/during the 3EUDC pre-conditioning but not during the NMVEG. The **Cmp_nt_npu_nox_vh_l_prio_fac** mapping will be calibrated for NMVEG and the **Cmp_nt_npu_nox_vh_h_prio_fac** mapping will be calibrated for the 3 EUDC. The switching between these two calibrations is performed based on the filtered speed. A first label **Cxx_nt_npu_vs_det_h** is used to switch from the low to the high map and a second label **Cxx_nt_npu_vs_det_l** does the opposite."

1375. Professor Plá accepted that the reason that there are two sets of maps forming the Velocity Dependent Saturation Condition is so that the LNT purges differently in the pre-conditioning cycles from the test itself. Professor Plá further accepted that the calibration strategy deliberately ensures there is only one purge during the NEDC test itself.

1376. Professor Tunestål accepted that the calibrations are the same inside and outside the test but the "*flip[…] from low speed condition to high speed condition" is designed for the specific purpose of ensuring that "you have sufficient number of purges during the pre-conditioning cycle, but not as much during the actual NEDC test"*. While Professor Tunestål does not in principle have an issue with calibrating the LNT to ensure reproducible results on an LNT, he states that *"it would be necessary to make sure that the same level of purging takes place during similar conditions as well*".

1377. This is a critical point. The Claimants appeared to suggest that the preconditioning "speed wedge" purges were solely there in preconditioning and to ensure the low baseline start for repeatability/reproducibility reasons. However

i) Mr Reverseau was clear that this calibration would also work on real life. As he put it:

> "So we design the second calibration in order to ensure on the pre-conditioning that we have the complete LNT purging and then this calibration is still active for the customer also. That means that if a customer exceeds the threshold of the filtered speed, explained here, it will be on the calibration on the pre-conditioning exactly in the same way."

ii) Professor Tunestål agreed that the "preconditioning purges" were not confined to preconditioning: that if a driver were driving at 100 kilometres per hour or 62 miles an hour on a motorway, or somewhere between 98 and 132 kilometres per hour, those same conditions would determine when a purge takes place in exactly the same way.

1378. Some play was made of an allegation that the purges in preconditioning were of a different duration to the purge in the NEDC. However that was a suggestion which was unpleaded and not explored on the evidence.

1379. Thus the preconditioning allegation is no different in nature to the NEDC purge allegation. Both are calibrations made to optimise performance on the NEDC, and they are thus properly to be regarded as cycle recognition devices; but they are not switch devices and they will be utilised in real world driving – or in Mr Reverseau's terms they are "*available to the customer*". Therefore it does not inevitably follow that they are CRDDs.

<u>CRDD: LNT cycle recognition purges and differential operation</u>

1380. The question then becomes whether they are nonetheless offensive – and defeat devices. That involves consideration of whether the optimised calibrations are sufficiently operational in real life and whether there is evidence to justify a conclusion that the calibrations were not designed to ensure differential operation in and out of test.

1381. As to the former point the testing did demonstrate the operation of these calibrations in on road real world driving conditions. The testing demonstrated regular purging at a range outside the speed windows which the Claimants have alleged circumscribed the purging. There was an average of 26.9 purges in the rural and motorway purging on RC2. As Mr Myhill rightly points out, this is not a case of "*an infinitesimal chance*" (AG Sharpston in *CLCV*) of the mode occurring outside the test.

1382. Further and as to the latter point, conceptually the pre-conditioning tests do not work as "*objectively intended to work less well out of test than in test*"; the preconditioning purges do not operate in test, and do operate in real life. They create purges when none would otherwise have happened. This cannot be a reduction in effectiveness in NOx reduction terms, but rather the reverse (though it may well have a negative impact on fuel efficiency).

1383. It is perhaps therefore unsurprising that, as Renault notes, the strategy has not been questioned by regulators at the time or subsequently.

1384. It also follows that the LNT purge calibrations would not be a DD based on the Claimants' "template" mode; They are part of the "menu" of calibrations used for the test, and are then used in the same way in real life.

1385. While the Claimants make complaint in relation to each of the individual conditions in the LNT calibration and contend that they are each separately DDs the argument was not really addressed to this. The overall thrust of the argument focussed more on an allegation that the on test calibration was such that it "*ensures that NOx levels at the end of the test are just below the limit".* This then forms the basis for an argument that the test calibration is (pace the template analysis) a defeat device because Renault could have calibrated for a test purge that would have led to better and/or more frequent purging out of test.

1386. There are two problems with this. First the calibration did work exactly the same off test as it did on test, so it is hard to see how this could fit a "defeat device" argument based on reduction in effectiveness. The argument is essentially a "could do better" argument; but as noted above, doing better, or doing as well as was technologically possible was not the standard imposed by the ER.

1387. The second problem is that the "just below the limit" allegation is not a fair reflection of the evidence in any event. It is based on a single correlation NEDC, not a Type 1 test: RC2 had PEMS equipment attached and was put through an NEDC cycle to calibrate the PEMS equipment. Unsurprisingly, given the extra load, the NOx emitted during the test was higher, by approximately 57%, than during the two Type 1 tests performed on RC2. It was, in short not a representative test permitting the factual basis for the allegation to be established. The result at type approval was well below the borderline figure and the NOx emissions in the relevant test (13 and 14) suggest that the figure (if recorded, which it was not) would have been well below the border.

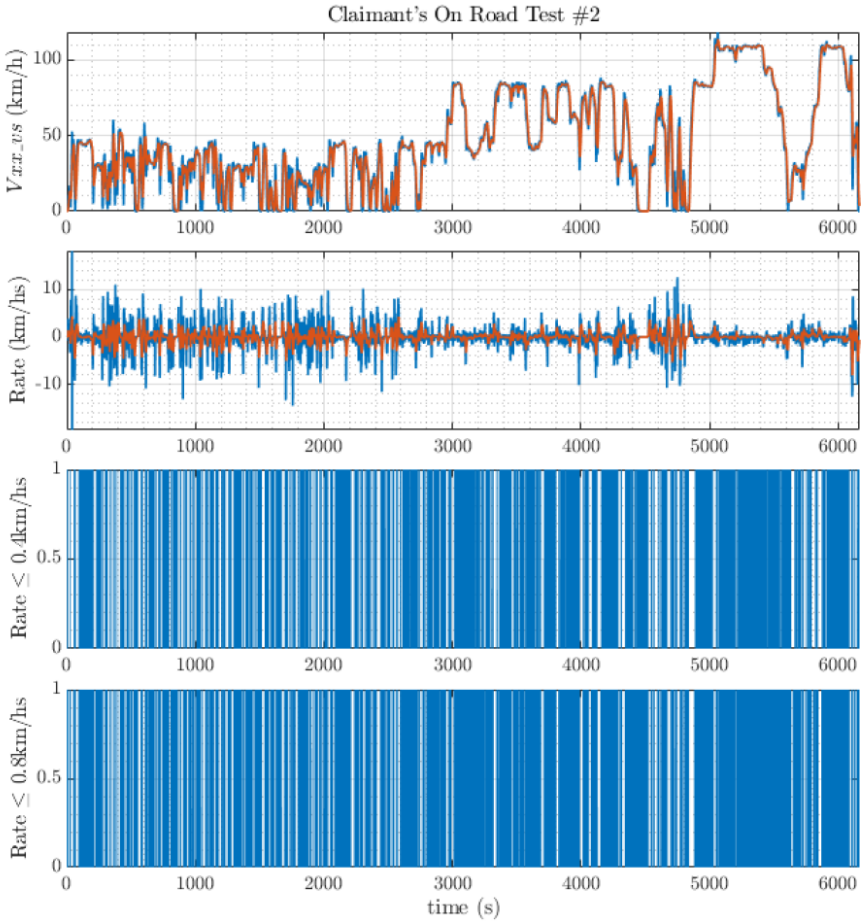
<u>Other conditions/alleged DDs</u>

1388. As regards the other alleged conditions/DDs on which there was focus:

i) Minimum 50kph condition – helps ensure catalyst temperature is sufficient to allow a purge, not criticised by Professor Tunestål, while suggested could do at lower temperatures where catalyst had heated up and there are issues with steadiness of speed which intersect. Similar issues elsewhere with LNT – where one gets to ultimately is – but process of learning;

ii) The condition to purge on Steady velocity was perhaps the best example in the trial of a Claimant attempt to have cake and eat it. Having criticised Ford for requiring

acceleration, they then criticised Renault (and Nissan) for requiring steady state – arguing that the Ford acceleration approach should have been adopted. The condition uses a filter which in effect averages the speed over about 10 seconds and compares averages to ensure that the conditions are sufficiently stable for a purge. As such it does not (contrary to initial concerns, and Professor Tunestål's view) mean conditions are rare. As the diagram shows (blue lines) the conditions are met much of the time (steady in this definition not being a very high bar):



iii) This was clearly one perfectly sensible way of doing it and on the evidence Mr Reverseau explained that he thought a more efficient purge would result. In reply the Claimants took the argument yet further by saying it was a PDD unless Renault calibrated for both steady state and acceleration. This provides another example of the "dream car" mentality;

iv) Air intake temperatures – the condition not to purge below 9ºC was not criticised by Professor Tunestål. Professor Plá indeed explains (consistently with other evidence) that LNT purging should be avoided at low vehicle speeds and temperatures. This was covered by AES/BES without any concern on the art of the regulator.

v) 160,000 off condition. there was no regulatory requirement for testing after 160,000km. This is moving well outside of any consideration of test versus real life.

1389. Renault admit that the calibration values applying to the LNT were "*selected to correspond to the Extra Urban Driving Cycle"* of the NEDC and that the LNT "*will be purged during the EUDC element of the NEDC test cycle itself*" but denies this is a CRDD. Renault's case is that the conditions were their way of ensuring repeatability of results in the test relying on Professor Plá's evidence that the Type 1 test can only be reliably standardised by starting the test with the LNT either empty or full. Less emphasis was put by them on ensuring the necessary conditions for good purging – because the conditions (in particular the speed wedges) would not ensure this.

1390. In ordinary driving, unless the driver happens to be driving steadily within unusual and precise speed wedges, the same will not occur: the car will not start with an empty catalyst; and will not regenerate in urban driving or much extra urban driving.

1391. Renault also say that the LNT strategy is not a PDD on the basis that: (i) purges occur with similar frequency on the NEDC and in NDC so there is no reduction in effectiveness, and (ii) it is justified under Article 5(2)(a), including thermal stress, fuel/soot in oil, DPF overloading from the Rich Phase if purges are too frequent, and (iii) purges cannot occur in more transient conditions.

1392. Another point which has come more into focus in closing is the Claimants' critique of the LNT purge conditions for test and NDC in that it is said that the "optimisation" to purge from a very full NOx trap is itself an issue because, it is said that a purge from a very full trap is less effective in the sense that it releases proportionately more untreated NOx by way of "NOx slip" than a purge at part capacity. This argument – which had an element of Goldilocks about it, since the Claimants had earlier critiqued the more frequent purging in pre-con – was also not solidly founded. In the first place the "car park" theory.

1393. In the second place the evidence suggested that NOx slip or breakthrough is inherent in all LNT purges – the technology is never 100% effective. So it is not a hazard simply of purging from full; and also the more frequent the purges, the more frequent the NOx slips and Professor Plá explained. There was no reliable evidence in the Renault litigation which would enable me to conclude that it was probable that proportionately more NOx was released from a single full purge from Renault vehicle than from (say) two purges from 50%. That there was some empirical evidence relating to a Nissan vehicle is not to the point. Apart from the fact that that is evidence in a separate action, one reason for retaining multiple manufacturers in this litigation, and indeed allowing multiple vehicles for both Nissan and Renault was because it was common ground that the same engine, calibrated slightly differently or operating in a different vehicle would perform differently.

THE NISSAN CSVS

Introduction and summary

1394. Details of the three Nissan CSVs are set out below. They are Qashqais – a medium sized family SUV. All three CSVs use a K9K Gen6 engine, with a maximum power of 81 kW (109 hp). The K9K engine was originally developed by Renault (and was also used in the Renault CSVs RC2 and RD2).

	Euro Standard	**Model**	**Engine**	**Type**	**Year of manufacture**	**ECS technologies**
NC1	5	Qashqai	K9K	Passenger Car	2014	HP & LP EGR
NC2	6b	Qashqai	K9K	Passenger Car	2016	HP & LP EGR, LNT
ND1	6b	Qashqai	K9K	Passenger Car	2018	HP & LP EGR, LNT

1395. Nissan received calibrations from Renault and accepted Renault's basic limits. Nissan did not undertake any of its own research or testing to see if the EGR or LNT limits could be expanded. Because Nissan did not develop the engine they did not fully understand the reasoning behind the calibration strategy in the vehicles. However Nissan had their own calibration team at the Nissan Technical Centre in Barcelona. Around 50 calibration engineers reported to Mr Miguel. Nissan calibrations were validated and tested by this team was done to ensure the vehicle worked properly in a range of conditions covering emissions and driveability. At least before Dieselgate the main focus was on passing the NEDC.

1396. There is therefore considerable overlap with the case against Renault.

Nissan Thermal window HP/LP

1397. All the CSVs use a calibrated minimum IAT/AAT threshold value for switching over from HP to LP EGR. The alleged windows for Nissan are similar to but far from identical with the Renault CSVs.

1398. LP EGR was deactivated below

i) 17°C IAT (NC1 and NC2),

ii) 8°C AAT (ND1 and NC2 update);

iii) There was also a coolant temperature threshold: 53°C (NC1) or 64°C (NC2/ND1) for LP EGR to operate.

1399. While obviously different evidence was called in the two cases the conclusions largely follow from the bigger issues which I have already covered. To the extent that there was distinct evidence on (for example) RIE, it effectively mirrored that in Renault. While it is true that none of the post-IPOC testing directly compares HP and LP EGR under the same operating conditions:

i) Nissan Mechanical JS: "*The combustion chamber temperature when in HP EGR mode will (all other things being equal) be higher and more NOx will be formed*";

ii) Mr Miguel also confirmed that by December 2015, the basic problem that had been identified with Nissan's NOx performance was the HP/LP EGR switch. He further confirmed that using HP EGR will likely increase NOx emissions;

iii) Mr Mortimer confirmed that LP EGR "*will give a greater degree of NOx reduction for the same EGR rate compared to HP EGR*" when it is operable "*Under the conditions where low pressure EGR is able to be active, compared to the conditions where high pressure EGR is active, most likely for a given speed/torque condition, you would have lower NOx with low pressure EGR. Because of the low pressure EGR advantages it runs colder, it displaces less air…*";

iv) Mr Miguel confirmed in evidence that one of the reasons for the poor performance of the Qashqai (CFs of 17.6 and 19.5) was the tests took place outside the updated low pressure/high pressure switch;

v) Renault's "internal measurement or estimation" of NOx was to expect CFs of 5-12 for track testing in "Homologation Conditions (17°C<Temp<35°C)" and a CF of 10-18 in "Climatic Conditions (0°C < Temp<17°C)", showing clearly far CFs in Cold Mode due to the use of HP EGR below 17°C. Likewise for the Updates (below 8°C), where the CFs in 'Homologation Conditions' were planned to be 2-4, and in 'Climatic Conditions' between 4-6.

1400. Indeed Nissan accepts, and invite a finding, that in the conditions in which it can operate safely, LP EGR has NOx reduction and fuel efficiency advantages to HP EGR and, all else being equal, will be more effective at reducing NOx than HP EGR for a given EGR rate.

1401. Also, and looking at NOx specifically, all else being equal the cooler LP EGR reduces NOx more than HP EGR for a given EGR rate because the combustion temperature is lower and it is denser (because it is colder) so more exhaust gas can be added than with HP EGR. Combustion stability is also better at lower temperature with LP EGR. As Mr Mortimer put it:

> "Q. In principle, low pressure EGR can provide considerably better NOx reduction than high pressure?
>
> A. Under the conditions where low pressure EGR is able to operate, it will give a greater degree of NOx reduction for the same EGR rate compared to high pressure EGR, but there are limitations on when you can use low pressure EGR."

1402. The only pushback against this related to efficiencies and benefits in the lower temperature range: it is substantively common ground that at a certain low temperature

HP EGR may offer a better trade-off between EGR rate and PM/HC/CO emissions than HP EGR. At low enough temperatures, application of HP EGR may even allow higher EGR rates compared to the application of LP EGR, whilst remaining inside combustion stability limits and better managing the trade-off between NOx and other emissions.

1403. What may be a good point for 8°C however does not seem likely to be so for17°C. Professor Plá confirmed: "*But yes, if the engine is able to work reasonably well, LP EGR improves NOx emissions of high pressure EGR*." It is therefore only when one gets to levels when the engine is unable to work reasonably well that one would expect HP EGR to be the better option on this front. At 8°C therefore where LP EGR could work one is very much on the borders of a conclusion that HP EGR would still lead to increased NOx. The read across from Renault (who did go down to 3°C) reinforces this difficulty.

1404. The Nissan submissions on 8°C therefore focussed on the risks, which might on one level go to justification. However in overall calibration terms the impression is that the issues which arise here fed into the decision to make the switch precisely where it was made. They concentrated first on risks of LP EGR at low temperature. The risk identified was the risk of condensation formation inside the intake system in that this liquid can freeze overnight and lead to the presence of ice inside the intake system leading to catastrophic engine damage turbocharger failure and so on. Professor Tunestål confirmed he agreed that the condensation risk was serious and could lead to catastrophic damage. While, as noted with Renault, that may be an issue by the time one gets to the 8°C limit, it certainly was not on the evidence a problem at the 17°C temperature.

1405. Having said that however, there is some evidence that Nissan encountered the hydraulic locking failure mode when the LP EGR activation temperature was reduced to 8°C AAT. There is also a Nissan presentation which records in-field failures associated with ice accumulation in the charge air cooler leading to major vehicle breakdowns. The failure mechanism and substantial remedial work required are described by Mr Mortimer. The cases span 2018-2021, and in 10 out of 21 cases (or 10 out of 40, depending on which bit of the slide one looks at) the starter motor was blown by the process described above. The problem was ultimately solved by the installation of a bumper mask.

1406. The issue here is that this is a very niche problem – featuring vehicles parked in sub-zero temperatures overnight during a cold snap in Northern Europe. It is not a combustion stability issue. It is not an issue which raises real dangers to the engine (all of the problems were solved with a fuse or possibly motor change and a cheap bumper mask already in existence for another model).

1407. While it is understandable that given the Renault Incidentology crisis both Renault and Nissan would be cautious about possible problems with new technology, if there were a single right answer I would conclude that this evidence could not itself justify the 8°C start. However plainly this was the borderlines of the engine working properly and hence of an area where LP EGR would be available. And the agreed expert position is that:

> "Exactly where the transition between HP and LP EGR can be, is very difficult to judge and dependent on many factors and there is no specific agreement on this point."

1408. As for Nissan's attempts to suggest that 17°C IAT corresponded in some conditions to the 3°C AAT, or that the same freezing concerns applied as were in play at 8C, they were

on any analysis overreaching the argument. While Professor Tunestål recognised that the delta between IAT and AAT can vary between 5°C and 15°C depending on the ambient conditions, it was clear on the totality of the evidence that the delta between AAT and IAT is more likely to be 5°C. Mr Mortimer's adjustment of his evidence on this from "excessive" to "seems somewhat conservative" in my assessment reflected a courteous criticism not an acceptance.

1409. It follows that:

i) NC1 and NC2 original are defeat devices, and indeed come very close to being categorised as CRDDs (boundary device), not least in the light of Mr Sauca's agreement that the 17-35°C range represented the homologation tests, with a margin. That I do not conclude that they are boundary devices is down to the less than consistent evidential picture on this – in particular the penumbra of uncertainty around the IAT/AAT delta, but also the distinction between perceiving a similarity and intending to replicate the NEDC window in circumstances where the NEDC itself was supposed to approximate to normal driving conditions. There is a danger of mistaking coincidence for causation. There is also the fact that Nissan were not originating these calibrations, but taking much on trust. That lack of clarity on the evidence is doubtless why this point was not fully pursued by the Claimants.

ii) ND1 and NC2 update are not defeat devices.

1410. There is no justification for any of the PDDs found in relation to this issue. The only risk credibly identified at the boundaries being operated is the charge air cooler issue which caused a starter motor failure. Even if this were any sort of a risk at the 17C threshold (which was not demonstrated) these were a scatter of incidents over 4 years, all of which were easily fixed. They never happened while the engine was running – only on start (or failure to start) with damage largely being of the order of a fuse, a duct or a mask. This does not, in my judgment fall within the ambit of the Article 5(2)(a) wording. It has none of the kinds of severity which are contemplated. It is, as the Claimants submit, best categorised as a risk of breakdown preventing the vehicle from starting.

1411. In the circumstances alternative technologies do not arise.

1412. Before leaving this subject it should perhaps be added that the above analyses purely by reference to the questions which are relevant for this NOx litigation. I entirely accept that questions of judgment and caution came into this calibration, at least at the early stage with LP EGR being a new technology. Having said that the initial calibration was plainly not done by reference to perceived risks.

Nissan Low temperature cut off

1413. It is agreed that NC1 cuts EGR off below 5/7°C IAT. The dispute between the parties is whether that modulation amounts to a DD and/or was justified.

1414. This allegation can be dealt with very briefly. The IAT/AAT delta varies based on a wide range of factors but the 5/7°C IAT equates, on an averaged basis, to freezing temperatures and temperatures often well below zero. It follows from the conclusion on NDC that the case on this alleged defeat device fails.

Nissan HT cut off

1415. It is agreed that NC1 cuts EGR above 33/35°C IAT, and NC2 cuts EGR above 37/39°C IAT (43/45°C post-update). The dispute between the parties is whether that modulation amounts to a DD and/or was justified.

1416. Again, in the light of the findings on normal driving conditions, and the finding which I have made as to the IAT/AAT delta above:

i) NC1 is on the borders of NDC (on 5C delta assumption it equates to28-30C). Full cut off of EGR will increase NOx so RIE would follow. On the earlier findings NC1 is (just) a defeat device.

ii) NC2 is not a defeat device.

1417. That conclusion harmonised nicely with the evidence: Professor Tunestål described the NC1 figure of 33/35°C as "too low" and the NC2 figure of 37/39°C as "borderline", while Mr Mortimer said C1 appeared conservative with hindsight, given the later widening, but reflected understandable caution in an early application, and NC2 seemed "reasonable".

1418. That leads into the question of justification for NC1. Nissan naturally placed much emphasis on the agreed risks associated with EGR operation, or excessive operation, at high temperatures are common ground: high PM emissions leading to DPF overloading, potential LP EGR sticking and associated cascading failure modes; exceeding the turbine inlet temperature; and engine overheating. However the evidence did not establish a risk of the severity necessary

Altitude/Atmospheric pressure

1419. Nissan accepted Renault's altitude cut-offs. NC1, NC2, and ND1 all cut EGR below 890/900 hPa. The dispute between the parties is whether that modulation amounts to a DD and/or was justified. For the reasons already given this falls outside the NDC boundary and therefore is not a DD.

1420. There appeared to be a secondary case that a cut off as opposed to a ramp down was a DD. However the basis for this, once the NDC boundary is passed was not made clear.

1421. In any event the evidence supported Nissan's case that there was in practice no on/off cutoff, but rather a gradual rampdown. This was a result of reduced boost pressure at a constant MAFSP between altitudes of 700m and 1000m.

> "There is an element of ramping down of EGR between 700 and 1,000 metres. If you accept that there's a 10% reduction in effective oxygen at 1,000 metres compared to zero metres and you are running 20% EGR at sea level and you maintain the same mass air flow set point and the boost is on its limit, you would be at 10% EGR rate by the time you get to 1,000 metres. So there's a natural reduction due to the fact that the EGR is a controlled by mass air flow set point. So you will have a reduction followed by a hard cut at 1,000 metres."

1422. Mr Mortimer says that while there is no generally accepted limit, since it will vary by vehicle, 1000m was a typical parameter used in the industry at the time and reasonable. Mr Mortimer's view that it was typical for the time is reflected in many comparable cut-offs in the other Sample Vehicles set out in the table above. 1,000m, it may be noted, sits above the current RDE normal range and slightly below the extended range. To the extent that Professor Tunestål for the Claimants maintained that it was appropriate rather to continue rampdown from 1000 to zero, I reject that criticism.

Nissan MAFSP/Correction Factor

1423. As with Renault, the MAFSP maps indirectly control the EGR rate. EGR may be cut off entirely if a high MAFSP is applied (in practice, this occurs far before the maximum MAFSP value of 1,500 mg/stk). The Claimants allege that the modulations to the maps by reference to IAT/AAT, engine speed and torque are PDDs. These modulations encompass both: (i) EGR derates, and (ii) EGR cuts (by setting a high MAFSP).

1424. The Claimants case on this, insofar as it is distinct from the individual temperature, torque etc components is not clear, despite Ms Dannreuther's best efforts. It is hard to understand what it adds, or to what vehicles it relates.

1425. The Claimants also allege that the Cold Mode correction factor maps are PDDs. They use MAFSP to cut-off EGR entirely below 60°C ECT/20°C. This is a more comprehensible allegation. Essentially this device is an engine coolant device and it prohibits EGR in cold mode until the engine coolant temperature is at 60°C (NC1 (Hot Mode)) or 20°C (NC2/ND1 (All modes)). In the low temperature NEDC this resulted in no switch on of LP EGR until about 10 minutes into the test. This resulted in a CF of 4.75, thereby demonstrating RIE resulting from this device.

1426. Nissan here rely on justification, based on the expert evidence as to engine protection; but all of this is rightly described by the Claimants as generic risk factors. Professor Tunestål thought 60°C was "*somewhat conservative*". Mr Mortimer says 60°C in NC1 in cold mode is conservative but likely a prudent response to risk in an early vehicle application. That may be prudent, but there is no proper justification for NC1.

1427. MASFP Correction factor is a PDD.

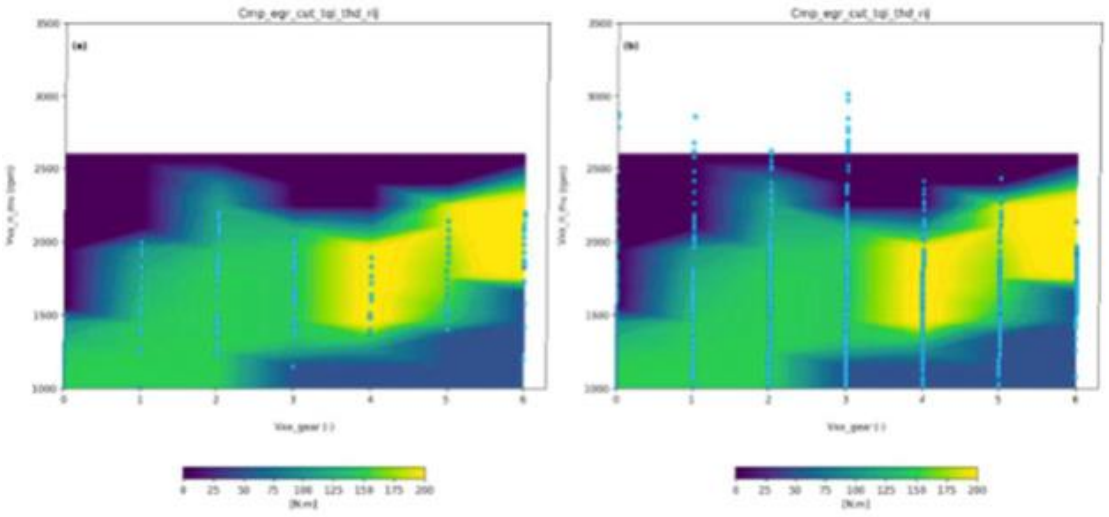
Nissan Torque cut off

1428. For Torque cut-offs Nissan followed Renault's standards but may have fine tuned depending on the weight and other features of the vehicle. The structure of the Torque cut-offs remained the same.

1429. As discussed in the context of Renault the existence of risks of excessive EGR at high engine speeds / torque are agreed, as is the need to modulate EGR for speed/torque. The issue concerns the proper evaluation of the calibration values and overall approach in the light of the expert evidence on NDC.

1430. Like Renault, the evidence indicates calibrating by reference to the NEDC, plus a margin (though not calibrating precisely to the test boundaries). As Mr Mortimer said the torque cut-offs have been matched to the NEDC, although "not exclusively" as seen in the Hot

Mode maps for NC1 below (NEDC left, Road test right, with blue dots showing test residency):



1431. Mr Mortimer's evidence reflected the same sense obtained in the Renault proceedings: he identified the difference between calibrating towards the NEDC and calibrating with a particular focus on the NEDC. The shape of the torque/speed modulation was consistent with the use of the NEDC reference cycle as the focus for development and validation but with a significant margin around this operation to ensure a wider operating range There is therefore no CRDD,

1432. Plainly the same maps operate in and out of test, which might fall within the template analysis. Here however there is no statistical evidence as to the respective proportions of time when the device operated in and out of test – although the impression from the Heitz plots is that (as with Renault) it is far more out of test than in test. On that basis and assuming broad consistency of the engine base calibration I would conclude that template analysis does not apply. Further on the wider analysis there is a setting which works less well out of test than on test. Nissan are wrong to say that there is no DD because many of the high speed/torque conditions in the operating window in the maps were not NDC. On their own case, given "the shape of the torque/speed mapping in the Nissan CSVs is consistent with the use of the NEDC as the primary reference cycle for emissions calibration" the torque cut off will logically operate without any possible safety justification well inside the NDC spectrum. On NDC most of Nissan's argument was based more on what the experts thought was reasonable than on the expert evidence on NDC. The torque cut offs applied for NC1 and NC2 are well below the limits indicated by that evidence. The 91% for ND1 is marginal. This is supported by Mr Mortimer's evidence that that NC1 and NC2 are relatively conservative.

1433. The evidence supporting RIE caused by the Torque cut offs is strong:

i) Mr Mortimer’s evidence is that NC1 cut off EGR 50% of the time in the road tests in Cold Mode, and 19% of the time in Hot Mode. For NC2, tests were only carried out in Hot Mode, where EGR was cut 20% of the time by the Hot Mode Torque Cut Off maps;

ii) Professor Tunestål confirmed that in Cold Mode for NC1, *"very little acceleration"* was required to activate the Torque Cut Off. in Hot Mode, "*a bit more so, but overtaking on a motorway or in rural driving would provoke these cuts*". Professor Tunestål confirmed that the effect of the cut offs was "*NOx emissions will increase drastically*". Accelerations are of course what produce the bulk of NOx emissions in practice;

iii) Mr Mortimer confirmed that the cut-offs will occur when high torque is being demanded from the vehicle, which are the areas that produce high NOx emissions. He accepted the Torque Cut Off would have a significant impact on NOx emissions;

iv) Mr Mortimer confirmed the torque cut-offs were contributing to the spike in NOx emissions towards the end of NC1's Modified Temperature 10°C NEDC.

1434. Again in the premises a justification argument cannot avail.

Nissan delayed start of LP EGR

1435. In addition to the ambient temperature HP/LP EGR Threshold, there is also an ECT threshold. Below that threshold, no LP EGR is available. In the CSVs, it is as follows:

i) NC1: 53°C

ii) NC2: 64°C

iii) ND1: 64°C

1436. The short answer to this device is that the switchover occurred on the NEDC test. It was therefore substantially (indeed entirely) included in the Type 1 test cycle within the meaning of Article 5(2)(c). and to the extent one pursues the Claimants' template approach, it is saved by that.

1437. This device is however interesting as demonstrating quite neatly to where the arguments go. *Prima facie* it is a DD: it delays the more NOx efficient EGR. It could not realistically be said to be within Article 5(2)(a) – there is a point at which safety issues would engage, but the particular points chosen cannot credibly be said to be shown to be at that level. There was broad agreement between the experts in relation to the risks associated with operating LP EGR at low engine coolant temperatures. It was not however specific to the relevant levels of 53°C (NC1) and 64°C (NC2 and ND1) and the rationale for these minimum conditions for LP EGR

1438. Thus while the exercise was a right thing to do at some point, there was a decision to be made about where to draw the line. As with Renault, the line chosen was not really criticised by Professor Tunestål. Nissan made that decision not solely be reference to NOx but also by reference to another very important pollutant, CO. Professor Tunestål did not criticise the resulting values, or the principle of seeking to achieve the best trade-off between NOx and CO, but considers that the methodology was overly focussed on the NEDC test cycle for the purpose of finding the best trade-off. Had the condition not been substantially included in the test, Nissan would find themselves having permitted a PDD, despite the fact that no real criticism came their way from either expert.

Nissan LNT

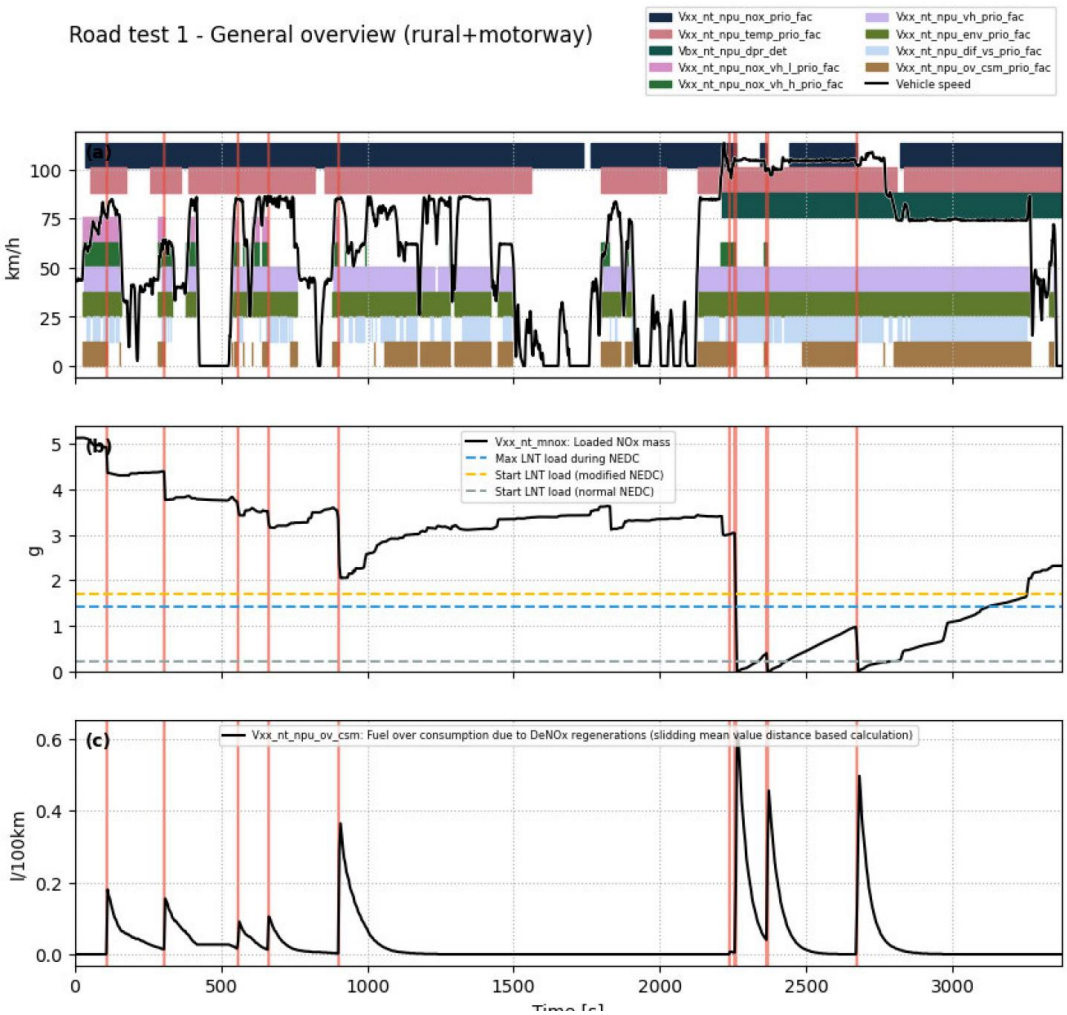
1439. The position in relation to the Nissan alleged LNT PDD/CRPDD is essentially identical to that of Renault. That is because the base calibrations in the LNT are Renault's and Nissan only undertook verification and fine-tuning work in respect of them and Nissan's LNT had to function within the boundaries set by Renault.

1440. As with Renault, the evidence was that the key aspect "speed wedges", designed to ensure that the LNT was purged before the NEDC, were available outside of the pre-conditioning and test. Mr Mortimer accepted (as is not in dispute) that, physically and chemically, there is nothing special about the speed windows of 66 to 72km/h or 94 to 102km/h, and that those speed ranges had been calibrated with the NEDC test in mind, to ensure consistent and repeatable purges under NEDC driving conditions. Mr Miguel explained that, because the calibration is the same whenever and however the vehicle is used, the settings to ensure appropriate pre-conditioning are part of the overall calibration and will occur in real life too.

1441. As with Renault, there was supportive evidence of purging outside the test. Averaging over Road Tests 1, 2 and 3 for each vehicle, in rural and motorway conditions, LNT purges took place more frequently off-cycle than during the NEDC Type 1 test. This was true both for NC2 and also ND1.

    i) In rural driving there was substantial LNT purging (meaning that the modelled NOx load dropped by approximately 1g or more) on numerous occasions (for example, the rural driving data for Road Test 1 in NC2 exhibited five purges (at approximately 100s, 250s, 550s, 650s and 900s), which noticeably reduced the modelled NOx load, especially the one at 900s, which removed about 1.5g of NOx;

    ii) Professor Tunestål under cross-examination by Ms Howard KC said: "*when you drive on the motorway at a fairly constant speed of around 100 kilometres per hour, then it just purges, purges, purges, purges, and the NOx −− the LNT load never gets above 0.25*".



iii) Dr Heitz also accepted that in the motorway sections of the test, there were numerous instances of complete purges (for example, in the motorway section of Road Test 1 of ND1;

iv) Professor Tunestål said that if the NEDC speed trace were followed in real-life driving, with the vehicle initially in the High-Velocity Configuration (as could well happen), it would purge 3 times (at 70, 100 and 100km/h) rather than the 1 time in the NEDC test. That underpins availability off-cycle.

1442. It therefore follows that:

i) There is no CRDD: the device is not a switch, or calibrated to the test;

ii) There is no DD based on the Claimants' "template" mode; They are part of the "menu" of calibrations used for the test and are then used in the same way in real life.

1443. As to reduction in effectiveness, if the Claimants wide approach to DDs is taken the case really comes down to:

i) The fact of no purges under 50km/h: but that is not a facet of the calibrations complained of, but rather of the technology;

ii) the theoretical argument predicated on the test purges being calibrated to perfection, such that in real life one would expect purges to be less perfect, or the LNT to be less effective as it got fuller.

1444. This however has no test or contemporaneous support. RIE would not be established.

1445. Again the individual conditions are not PDDs. It is notable that Professor Tunestål himself did not consider (a) the Steady Velocity Condition, (b) the Fuel Overconsumption Condition, (c) the LNT Temperature Condition, and (d) the LNT Temperature Dependent Saturation Condition to be defeat devices. Professor Tunestål also accepted that the IAT Condition was "not entirely" a defeat device, on the basis that the temperature calibrations clearly had no relationship whatsoever to the temperatures found in the NEDC Type 1 test. There seems to be no evidence to support the Claimants case that "*Each condition could have been widened*", indeed the Claimants themselves hedge with "*subject to appropriate testing and validation."* This approach appears to proceed from the "dream car" fallacy namely a faulty premise that unless every aspect is calibrated to the very limit of safety it is a DD. That of course contradicts the agreed evidence as to the role of judgment.

1446. As for the LNT purge shut off after 160,000, this deactivates purges after 160,000 km, except in the 66-72 km/h and 94-102 ranges in the High Velocity Configuration. Mr Mortimer accepted the condition was not necessary; on the basis it was removed from ND1. While he accepted the reason for it could "potentially" be an intense focus on being able to pass the NEDC test but no particular interest in real world driving, that does not make sense, given that the test is not going to be performed on an antique vehicle and the upper boundary even for in use conformity testing is 100,000km. This is not an in test/out of test distinction even in conception. And further with speed wedges still triggering purges if the vehicle were tested at this late stage in its life there would be no differential operation. As Nissan put it in closing:

> "While it is not in dispute that this was not a necessary calibration to include, as it was not included in the Step 1 update or the calibration of ND1, that is not the test for whether a technology constitutes a defeat device. Nissan submits that a calibration which "turns down" the LNT purging beyond the durability and in-use testing limits specified by the relevant regulatory framework (where there is no ongoing obligation to ensure in-service conformity) does not undermine the aims of the regulatory framework and cannot be a defeat device."

Summary of outcomes on the DD allegations

		CRDD	**Template and primary findings**	**Claimants' full approach (evidence on RIE)**
1.	Mercedes CTS	✓	x	No RIE
2.	Mercedes Base Maps			No RIE
3.	Mercedes Cooler /Bypass		x	x
4.	Mercedes Air temp		Partial if RIE	No RIE
5.	Mercedes Engine Temp			No RIE
6.	MBC1 Idle		x	No RIE
7.	Mercedes Engine Start		x	No RIE
8.	Mercedes Noise		✓	✓
9.	Mercedes Atmospheric pressure		x	No RIE
10.	Mercedes SCR Dosing		x	x
11.	Ford Torque	x	x	No RIE
12.	Ford Temperature		FC5 FD3 if RIE	No RIE
13.	Ford Atmospheric Pressure		FD3, FD1 and FC6 if RIE	No RIE
14.	Ford LNT	x	x	✓
15.	Ford SCR		x	X (Art 5(2)(c)
16.	Ford 6th Gear		x	No RIE
17.	PCD Split	✓	✓	✓
18.	PCD Atmospheric pressure		x	✓
19.	PCD Temperature		x	No RIE
20.	PCD Torque/Speed		x	No RIE
21.	PCD Euro 6 combustion modes		Partial, if RIE	No RIE
22.	PCD Euro 6 SCR	x	✓ if RIE	✓
23.	Renault temperature		mixed	✓
24.	Renault HT cut off		x	No RIE
25.	Renault Warm up 4th and 5th Gears RC2		✓	✓
26.	Renault Correction factor		✓	✓ (Art 5(2)(c) RC3
27.	Renault Torque cut off	x	✓	✓
28.	Renault delayed start up		x	Art 5(2)(c)
29.	Renault Low Atmospheric pressure		x	✓
30.	Renault LNT	x	x	No RIE
31.	Nissan temperature HP/LP		✓	✓
32.	Nissan Low temperature cut off		x	x
33.	Nissan HT cut off		x	x

34.	Nissan Correction Factor		✓	✓
35.	Nissan Torque cut off		✓	✓
36.	Nissan delayed start of LP EGR		x	Art 5(2)(c)
37.	Nissan atmospheric pressure		x	x
38.	Nissan LNT	x	x	No RIE

PART 3

APPENDIX 1: REPRESENTATION

Claimant Lead Firms	Claimant Counsel	Chambers
Pogust Goodhead **Leigh Day** **Keller Postman** **Milberg London LLP** **Hausfeld** **Johnson Law Group** **Bond Turner**	Thomas De La Mare KC	Blackstone
	Oliver Campbell KC	Henderson
	Ben Jaffey KC	Blackstone
	Adam Kramer KC	3 Verulam Buildings
	Gareth Shires	Exchange
	Joanna Buckley	Matrix
	Jessica Van Der Meer	2 Temple Gardens
	Kate Boakes	Matrix
	Sam Stevens	2 Temple Gardens
	Anna Dannreuther	2 Temple Gardens
	Catherine Arnold	Matrix
	Isha Shakir	Henderson
	Rebecca Brown	Fountain Court
	Jessica Sutton	Matrix
Case/Defendant Firms	**Defendant Counsel**	**Chambers**
Mercedes **(Herbert Smith Freehills Kramer (HSF))**	Helen Davies KC	Brick Court
	Malcolm Sheehan KC	Henderson
	Richard Blakeley KC	Brick Court
	James Purnell KC	Henderson
	Zahra Al-Rikabi	Brick Court
	Lia Moses	Henderson
	Jonathan Scott	Brick Court
	Jack Castle	Henderson
	Jessie Ingle	Brick Court
	William Moody	Henderson
Ford (Hogan Lovells)	Neil Moody KC	2 Temple Gardens
	George Peretz KC	Monckton
	Sonia Nolten KC	2 Temple Gardens
	George Hilton	Monckton

	Benjamin Phelps	2 Temple Gardens
	Kate Legh	2 Temple Gardens
	Georgia Terry	Maitland
Renault Nissan (Signature Litigation) (Renault)	Alexander Antelme KC	Crown Office
	Richard Sage	Crown Office
	David Myhill	Crown Office
	Frederick Simpson	Crown Office
Renault Nissan (Signature Litigation) (Renault) Hogan Lovells (Nissan)	Stephen Auld KC	One Essex Court
	Anneli Howard KC	Monckton
	Michael d'Arcy	One Essex Court
	Simon Gilson	One Essex Court
	Katherine Boucher	One Essex Court
Peugeot Citroen (Kennedys)	John Taylor KC	Fountain Court
	James Cutress KC	Fountain Court
	Samuel Ritchie	Fountain Court
	Christopher Monaghan	Fountain Court
FCA (Kennedys)	Simon Atrill KC	Fountain Court
	Sam Hussaini	Fountain Court
Suzuki (Hogan Lovells)	Charles Dougherty KC	2 Temple Gardens
	James Partridge	2 Temple Gardens
VW (Hogan Lovells)	Prashant Popat KC	Henderson
	Kathleen Donnelly KC	Henderson
	Thomas Evans	Henderson
Porsche (Hogan Lovells)	Geraint Webb KC	Henderson
	Arnold Ayoo	Maitland
	Douglas Maxwell	Henderson
	Lucy McCormick	Henderson
	Celia Oldham	Henderson
BMW (Hogan Lovells)	Charles Dougherty KC	2 Temple Gardens
	Thomas Fairclough	2 Temple Gardens
Volvo (DLA Piper)	Peter De Verneuil Smith KC	3 Verulam Buildings
	Judy Fu	3VB
JLR (CMS)	Andrew Kinnier KC	Henderson
	James White	Henderson
Vauxhall (Cleary Gottlieb Steen & Hamilton)	Leigh-Ann Mulcahy KC	Fountain Court
	Charlotte Tan	Brick Court
	Alexander Thompson	Twenty Essex
Mazda (Hogan Lovells)	Stephen Auld KC	One Essex Court

	Noel Dilworth	Henderson
Toyota (HSF)	Neil Kitchener KC	One Essex Court
	Sophie Weber	One Essex Court
	Rowan Stennett	Blackstone
Hyundai-Kia (Quinn Emanuel)	Victoria Wakefield KC	Brick Court
	Joshua Crow	One Essex Court

APPENDIX 2

Abbreviation/Term	Full Definition
1970 TA Directive	Council Directive 70/156/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers OJEC L 42, 23.2.1970
2009 Regulations	The Road Vehicles (Approval) Regulations 2009 (SI 2009/717)
2020 Regulations	Road Vehicles (Approval) Regulations 2020 (SI 2020/818)
AAIB	Air Accident Investigation Branch
AAT	Ambient Air Temperature
ACEA	European Automobile Manufacturers' Association
ACU	Additional Control Unit
AECC	Association for Emissions, Control and Climate
AERO	Air & EGR Request Optimisation
AES	Auxiliary Emission Strategy
AECD	Auxiliary Emission Control Device
ADBLUE	Urea based solution, which when injected into hot exhaust gas, decompress to release gaseous ammonia. This NH3 is stored on the SCR Catalyst where it participates in a catalysed reduction reaction with NOx
AFR	Air-to-Fuel Ratio
AG	Advocate General
ALGLO	Additional Lead Group Litigation Order
ASC	Ammonia Slip Catalyst
ASDS	Ammonia Storage and Delivery System
ATD	Agreed Technical Document
BAT	Best Available Technology/Techniques
BBN	Bilan Batterie Nul
BEIS	Department for Business, Energy, & Industrial Strategy
BES	Base Emissions Strategy
BGH	Bundesgerichtshof (German Federal Court of Justice)
BMVI	German Federal Ministry of Transport and Digital Infrastructure
BOC	Breach of Contract
BoSD	Breach of Statutory Duty
CAA	US Clean Air Act 1963
CAC	Charge Air Cooler
CADC	Common Artemis Driving Cycle
CAF	Condition Authority Function
CAFÉ	Clear Air For Europe
CAT	Charge Air Temperature

CATD	Contested Agreed Technical Document
CCA 1974	Consumer Credit Act 1974
CC Mode	Consumption Control Mode
CCF	Comparative Conformity Factors
CCM	Controlled Consumption Mode
CF	Conformity Factors
CJEU	Court of Justice of the European Union
CLCV	Consommation Logement Cadre de Vie
CMJ	Costs Management Judgment
CO	Carbon Monoxide
CO^2	Carbon Dioxide
CoC	Certificate of Conformity
CPR	Civil Procedure Rules
CPUT 2008	Consumer Protection under Unfair Trading Regulations 2008
CRDD	Cycle Recognition Defeat Device
CRDD (DM)	Cycle Recognition Defeat Device (Differential Mode)
CRF	Common Regulatory Framework
CRO	Confidentiality Ring Order
Crossley 1	*Crossley & Ors v VW AG* [2019] EWHC 783 (QB)
Crossley 2	*Crossley v Volkswagen AG* 1 All ER (Comm) 107
CSV	Core Sample Vehicle
CTSM	Coolant Temperature Setpoint Manipulation
C&U	Construction & Use
DD	Defeat Devices
DDH	De-Designation Hearing
DEF	Diesel Exhaust Fluid
DEFRA	Department for the Environment, Food and Rural Affairs
DE-NOx	An exhaust aftertreatment system by which Nitrogen Dioxide stored in the LNT Catalyst is converted or purged, in periodic 'rich spike' modes in the engine
DESOx	The periodic removal of SOx from an LNT
DF	Deterioration Factor
DFT	UK Department for Transport
DGCCRF	General Directorate for Consumer Affairs, Competition and Fraud control
DGEC	France's Directorate General for Energy and Climate
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
DS	Judgment of 14 July 2022 *DS v Porsche Inter Auto GmbH & Co and Volkswagen AG*
DUH	Judgment of 8 November 2022 *Deutsche Umwelthilfe eV & Co v Volkswagen AG*
DR	Dosing Release
EATS	Exhaust Aftertreatment System
ECE	Urban (lower average vehicle speed) phase of the NEDC

ECMT	European Conference of Ministers of Transport
ECS	Emissions Control System
ECT	Engine Coolant Temperature
ECU	Engine Control Units
EGR	Exhaust Gas Recirculation
EM	Engine Measures
ENGINE OUT NOx	NOx emissions that exit the combustion chamber before aftertreatment
EOM	Engine Operating Modes
EPA	Environmental Protection Agency
ER	Emissions Regulation (Regulation 715/2007)
ETA	Emissions Type Approval
EU CRF	EU common regulatory framework, comprising the ER, given further effect by the IR, and the FD/FR
EUDC	Extra-Urban Drive Cycle
EURO 5	Standard in Annex I to the Emissions Regulation, the applicable limit for the NOx emissions of diesel vehicles, measured in a laboratory pursuant to the NEDC test, between 180 and 280 mg/km, depending on the category and class of vehicle
EURO 6b	A standard for type approval under (EC) 715/2007 with the applicable limit for NOx emissions of diesel vehicles, pursuant to the NEDC test, to be between 80 and 125 mg/km, depending on category and class of vehicle
EURO 6c	A standard for type approval under (EC) 715/2007 with the applicable limit for NOx emissions of diesel vehicles, pursuant to more realistic laboratory WLTP testing, to be between 80 and 125 mg/km, depending on category and class of vehicle
EURO 6d	A standard for type approval under (EC) 715/2007 with the applicable limit for NOx emissions of diesel vehicles, pursuant to mandatory Real Driving Emissions (RDE) testing, to be limited to 80mg/km
EURO 6d-TEMP	New Type Approvals from 1 September 2017, and new registrations from 1 September 2019
EURO 6e	A standard for type approval under (EC) 715/2007 pursuant to mandatory Real Driving Emissions (RDE) testing, and lower conformity factors for the tests than the previous Euro 6 standard of 1.10 for NOx and 1.32 for PN emissions
EURO 7	Standard under Regulation (EU) 2024/1257, which will eventually supersede the current Euro 6 regulation
EUWA 2018	European Union Withdrawal Act 2018
Farley	*Farley v Paymaster* [2025] EWCA Civ 1117
FD	Framework Directive

FL	Fill Level Mode
FMTA	Federal Motor Transport Authority
FOS	Financial Ombudsmen Service
FR	EU Regulation 2018/858
FSA	Financial Services Authority
GB CRF	The UK's version of the EU Common Regulatory Framework
GLO	Group Litigation Order
GPOC	General Power of Competence
GPSD	General Product Safety Directive
GSI	Gear Shift Indicator
GSMB Invest	Judgment of 14 July 2022 *GSMB Invest GmbH & Co v Auto Krainer GesmbH*
H^2O	Water
HC	Hydrocarbons
HGV	Heavy Goods Vehicle
HOLISTIC ARGUMENT	Argument that if NOx were increased but e.g. HC reduced, it could not be said that there was a reduction in effectiveness of the ECS (name originally used by VW in *Crossley 1*)
HOOD	High Output Optimised Diesel
HP	High Pressure
IAT	Intake Air Temperature
IF	Initial Firmware
IPOC	Individual Particulars of Claim
IPCD	Implementation Period Completion Day
IR	Implementing Regulation
JRC	European Commission's Joint Research Centre
JTP	Joint Testing Programme
KBA	Federal Motor Transport Authority of Germany
KBA TRIAL/JUDGMENT	The two-week trial in October 2024 dealing with the KBA Issues (as defined in the March 2024 CMC Order), with judgment at *Cavallari v Mercedes* [2024] EWHC 2904 (KB)
KETCH	An industry term for the NEDC preconditioning cycle
KFTC	Korean Fair Trade Commission
Ki Factor	Regeneration Adjustment Factor
LCV	Light Commercial Vehicles
Lipton	*Lipton v BA Cityflyer* [2025] AC 154
LNT	Lean NOx Trap
LP	Low Pressure
MAF	Mass Air Flow
MAF Sensor	Mass Airflow Sensor
MAFSP	Mass Air Flow Set Point
MDA	Master Development Agreement
ME	Mechanical Engineering
MIL	Malfunction Indicator Light

MRD	Mandatory Recall Decision
MS	Member State
N^2	Nitrogen
NC	Neutral Citation
NCCM	Non-Controlled Consumption Mode
NDC	Normal Driving Conditions
NDR	New Document Regulation
NEDC	New European Driving Cycle
NH^3	Ammonia
NH3 SLIP	Unreacted ammonia which may pass through the SCR Catalyst and be emitted via the tailpipe
NIR	New Implementing Regulation
NMC	NoX Monitoring Committee
NMVEG	New Motor Vehicle Emission Group
NO	Nitric Oxide
NO^2	Nitrogen Dioxides
NOx	Nitrogen Oxides
NOx SLIP	In LNT, additional NOx passing through the catalyst released out of the tailpipe
NTCE	Nissan Technical Centre Europe
NTE	Not To Exceed
NVH	Noise, Vibration and Harshness
OBD	On-Board Diagnostic System
OED	Oxford English Dictionary
OEM	Original Equipment Manufacturer
OLD EMISSIONS DIRECTIVE	Commission Directive 77/102/EEC of 30 November 1976 adapting to technical progress Council Directive 70/220/EEC of 20 March 1970 on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles,
OGH	Oberster Gerichtshof (Austrian Supreme Court)
OIDEF	Overarching Defence
OLG	Oberlandesgericht (The Higher Regional Court of Germany)
PCD	Peugeot Citroën DS
PC's	Passenger Cars
PDD	Prohibited Defeat Devices
PEMS	Portable Emissions Measurement System
PM	Particulate matter
PN	Particulate Number
P-SCR	Passive SCR System
PTR	Pre-Trial Review
PU	Potential Update
PU2	Potential Update 2
QB	Judgment of 21 March 2023 *QB v Mercedes-Benz Group AG*

RAPCS	Regent Pollution Control System
RDE	Real Driving Emissions
RDE1	Commission Regulation (EU) 2016/427
RDE2	Commission Regulation (EU) 2016/646
RDE3	Commission Regulation (EU) 2017/1154
RDE4	Commission Regulation (EU) 2018/1832
RDE5	Commission Regulation (EU) 2023/443
RECNVOU	Reasonably expected conditions of normal vehicle operation and use
REUL ACT 2023	Retained EU Law Act 2023
RIE	Reduction in Effectiveness
RHN	Regulation, Type Approval and Standards
Rogers	*Rogers v Hoyle* [2015] QB 265
RPM	Revolutions Per Minute
RTA 1988	Road Traffic Act 1988
SCR	Selective Catalytic Reduction
SDPA	Short term DeNOx Purge Ability
SOx	Sulphur Oxides
SO^2	Sulphur dioxide
SQ	Satisfaction Quality
STTG	Base System Transbase Powertrain Group
TA	Type Approval
TAA	Type Approval Authority
TCR	Conversion of NOx to nitrogen and water
TCRD	Test Cycle Recognition Devices
TCMV	EU's Technical Committee on Motor Vehicles
TDC	Tope Dead Centre
TEC	Treaty establishing European Community
TEEC	Treaty establishing European Economic Community
TFEU	Treaty on the Functioning of the European Union
THC	Tetrahydrocannabinol
TID	Test Inclusion Defence
T&E	Transport and Environment
TORQUE	The measure of force which can cause an object to rotate around an axis
UDC	Urban Drive Cycle
UDL	Urea Deposit Limit
UF	Updated Firmware
UNECE	United Nations Economic Commission for Europe
V*apos	Numerical product of speed times positive acceleration
VCA	UK Vehicle Certification Agency
VDA	German Association of the Automotive Industry
VUDs	Voluntary Update Decisions
WF	Windsor Framework
WLTC	Worldwide Light Vehicles Test Cycles
WLTP	Worldwide Harmonised Light vehicles Test Procedure

WVTA	Whole Vehicle Type Approval

Appendix A: Summary of the Emissions Control System on each Sample Vehicle

Sample Vehicle Designation	Make	Model	Euro standard	EGR	HP-EGR	LP-EGR	EGR Cooling	SCR	Passive SCR	LNT	Other EATS
MBC1	Mercedes	E220 CDI	5b	Y	Cooled and Uncooled	N	Y	N	N	N	DOC, DPF
MBC6	Mercedes	ML350 BLUETEC 4MATIC	6b	Y	Cooled and Uncooled	N	Y	Y	N	N	DOC, DPF
MBD1	Mercedes	C220 d	6b	Y	Cooled and Uncooled	N	Y	Y	N	N	DOC, DPF
MBD6	Mercedes	GLC 350 d 4MATIC	6b	Y	Cooled and Uncooled	N	Y	Y	N	N	DOC, DPF
FC1	Ford	Focus	5b	Y	Y	N	Y	N	N	N	DOC + DPF
FC5	Ford	Transit	5b	Y	Y	N	Y	N	N	N	DOC + DPF
FC6	Ford	C-Max	6b	Y	Y	N	Y	N	Y	Y	DPF
FD1	Ford	Transit	6b	Y	Y	N	Y	Y	N	N	DOC + DPF
FD3	Ford	Fiesta	5b	Y	Y	N	Y	N	N	N	DOC + DPF
FD5	Ford	Mondeo	6b	Y	Y	N	Y	N	Y	Y	DPF
PCDC3	Citroen	C4 Cactus	6b	Y	Y	N	N	Y	N	N	DOC + DPF

Sample Vehicle Designation	Make	Model	Euro standard	EGR	HP-EGR	LP-EGR	EGR Cooling	SCR	Passive SCR	LNT	Other EATS
PCDC6	Citroen	C4 Picasso	5b	Y	Y	N	Y	N	N	N	DOC + DPF
PCDD1	Peugeot	2008	6b	Y	Y	N	N	Y	N	N	DOC + DPF
PCDD4	Peugeot	2008	5b	Y	Y	N	Y	N	N	N	DOC + DPF
NC1	Nissan	Qashqai	5b+	Y	Y	Y	N	N	N	N	DOC + DPF
NC2	Nissan	Qashqai	6b	Y	Y	Y	N	N	N	Y	DOC + DPF
ND1	Nissan	Qashqai	6b	Y	Y	Y	N	N	N	Y	DOC + DPF
RC2	Renault	Captur	6b	Y	Y	Y	N	N	N	Y	DOC + DPF
RC3	Renault	Trafic	5	Y	Y	Y	N	N	N	N	DOC + DPF
RD2	Renault	Captur	6b	Y	Y	Y	N	N	N	Y	DOC + DPF

Appendix B: Glossary of terms

Term	Definition
Active regeneration	The periodic regeneration of a DPF where the exhaust gas temperature is purposely raised sufficiently high enough for the trapped PM to be oxidised.
Actuators	Devices that change the physical state of a component, e.g. the position of a valve.
ACU	Additional Control Unit.
AdBlue	Commercial name for DEF ammonia precursor. AdBlue is an aqueous solution of urea.
AFR	Air-to-Fuel Ratio.
Air-fuel mixture	The mixture which is produced as a result of the combination of intake gases and fuel in the combustion chamber.
Ammonia Slip	Unreacted ammonia which may pass through the SCR Catalyst and be emitted via the tailpipe.
Calibration	The part of the Firmware which defines the values of each calibratable variable (parameter or "label"), including maps, curves and individual values, that are used as inputs to each function in the Software.
CO_2	Chemical notation for carbon dioxide.
CO	Chemical notation for carbon monoxide.
Charge Air Cooler	A heat exchanger located downstream of the turbocharger's compressor which cools the air that has been heated by the turbocharger's compressor.
Combustion Products	Products of the combustion process, primarily CO_2, H_2O, NOx, CO, HC and PM (and also SOx).
DEF	Diesel Exhaust Fluid, commercially known as 'AdBlue', a mixture of urea and water.
DeSOx	The periodic removal of SOx from an LNT.
DOC	Diesel Oxidation Catalyst: a catalytic device that converts, through oxidation, HC, some PM, and CO into water vapor and CO_2.
DPF	Diesel Particulate Filter: a device which physically captures diesel particulates preventing their discharge from the tailpipe.
Driving Cycle	A prescribed profile of vehicle speed (and for some cycles, gear shift points) as a function of time, typically used during a regulated emissions test performed in a vehicle emissions test laboratory.
EATS	Exhaust Aftertreatment System, used to refer to one sub-system, e.g. the DPF, or collectively all the sub-systems in a vehicle's exhaust system.
ECS	Emissions Control System.
ECU	Engine Control Unit: a specialised computer that manages the control of a vehicle's engine.

Term	Definition
EGR	Exhaust Gas Recirculation: a process which recirculates exhaust gases back into the combustion chamber of the engine.
EGR Cooler	Heat exchanger which reduces the temperature of the EGR gas passing through it.
EGR Cooler Bypass	EGR pathway in parallel to an EGR Cooler giving the option of running cooled or uncooled EGR to suit different engine operation conditions.
EGR Rate	The amount of recirculated exhaust gas inducted into the combustion chamber relative to the sum of fresh air and recirculated exhaust gas inducted, commonly stated as a percentage.
Firmware	The computer program embedded in the ECU.
H_2O	Chemical notation for water.
HP-EGR	High-Pressure Exhaust Gas Recirculation: an EGR system which directs exhaust gasses from the exhaust manifold, upstream of the turbocharger turbine, into the intake manifold, downstream of the turbocharger compressor.
HC	Hydrocarbons: the generic designation for a range of chemical organic compounds in the engine exhaust containing carbon and hydrogen.
Injection timing	The injection timing describes when, relative to the piston and crankshaft position, fuel is injected into the combustion chamber. If timing is moved earlier, it is “advanced”, if timing is moved later it is “retarded”.
Loading Phase	The phase where NOx emissions are collected within an LNT catalyst when the engine is running on a lean mixture by oxidation of NO to NO_2, catalysed by precious metals on the surface of the support material, and by adsorption of NO_2 onto the storage element.
LNT	Lean NOx Trap: a system which collects NOx emissions within a catalyst as the engine is running on a lean mixture and requires periodic regeneration to remove stored by chemical reduction of NOx.
LP-EGR	Low-Pressure Exhaust Gas Recirculation: a system which has an EGR circuit being placed after the turbocharger turbine and, sometimes, after an after-treatment catalyst.
MAF	Mass Air Flow: the mass flow rate of fresh air entering the combustion chambers.
MAFSP	Mass Air Flow Set Point: which is the desired or target amount of intake air to be delivered to the engine
MIL	Malfunction Indicator Light, a light on the vehicle dashboard that indicates a malfunction to the driver.
NEDC	New European Driving Cycle: the driving cycle.
N_2	Chemical notation for molecules of nitrogen.
NH_3	Chemical notation for ammonia.
NO	Chemical notation for nitrogen monoxide or “nitrous oxide”.
NO_2	Chemical notation for nitrogen dioxide.

Term	Definition
NOx	Oxides of nitrogen: the collective term for the sum of NO and NO_2.
O_2	Chemical notation for molecules of oxygen.
OBD	A functionality of the ECU, which monitors various vehicle systems and identifies potential malfunctions.
Passive regeneration	The regeneration of a DPF using NO_2 in the exhaust gas, which occurs naturally whenever the conditions are conducive.
PM	Particulate Matter: a mixture of small particles and liquid droplets generally consisting of soot, organic compounds, inorganic compounds, and metal particles.
PN	"Particulate Number" – as per Reg (EU) 2016/427, Annex IIIA, (1.2.18.).
Purging Phase	The phase where the NOx stored in an LNT Catalyst is converted or purged during a regeneration process which involves a periodic "rich spike" mode to allow the reduction of the stored NOx.
P-SCR	Passive Selective Catalytic Reduction: a system which pairs a LNT with an SCR without DEF injection.
RDE	Real Driving Emissions.
Regulated emissions test	A test consisting of operating a vehicle over a prescribed driving cycle in a vehicle emissions test laboratory, during which the exhaust gas exiting the vehicle's tailpipe is sampled and the masses of each regulated emission are measured.
SCR	Selective Catalytic Reduction, a system that uses a catalyst to reduce NOx in the exhaust gas.
SCR Catalyst	The component of an SCR system, consisting of a substrate upon which a chemical wash-coat is applied which catalyses the reduction reaction.
Sensors	Devices installed in the vehicle to measure certain data which can be transmitted to a control unit, e.g. the ECU.
SO_2	Chemical notation for Sulphur Dioxide.
SOx	Oxides of sulphur, which result from the oxidisation of sulphur that is found in fuel and lubricating oil.
Tailpipe	A vehicle's tailpipe is the visible end portion of the exhaust system where exhaust gases exit the vehicle to atmosphere.
TDC	Top-Dead Centre: position of the piston reached at the end of an upward stroke and corresponding to the minimum volume of the combustion chamber.
Vehicle emissions test laboratory	A facility where the vehicle is operated on a chassis dynamometer (also called a "rolling road") where regulated emissions tests are performed. Typically, the vehicle is operated over a prescribed driving cycle during which the chassis dynamometer applies loads to the vehicle's wheels to simulate inertia and aerodynamic drag forces and rolling resistance.

Term	Definition
WLTC	Worldwide harmonised Light vehicles Test Cycle, the driving cycle used with the WLTP.
WLTP	Worldwide harmonised Light vehicles Test Procedure, the procedures used in which a vehicle is tested over the WLTC.

APPENDIX 3

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Introduction

1. This document addresses technical aspects of the above claims as provided for in paragraph 56 of the Order of 10 May 2024 (the "**Order**"). This document adopts terms used in the Order. The contents of this document are intended to assist the Court by introducing the technical issues in the above NOx emissions group claims and provide the Court with factual material relevant to determining the PDD Trial issues for all parties.

2. Diagrams in this document are presented for illustrative purposes only. These diagrams are not to scale, are simplified, and may not depict the actual relative sizes, locations or characteristics of the components mentioned. The descriptions of technical and engineering concepts are also simplified, and in many instances the detailed operation and complexities differ from manufacturer to manufacturer, and vehicle to vehicle, and thus will likely need to be developed further in expert evidence insofar as it concerns the Lead GLOs (and, in due course, the Non-ALGLOs).

3. Nothing in this document is intended to affect any party's position on any matter of law or legal interpretation. It is also not intended to affect any party's position on any specific factual matter. No party with permission to adduce expert evidence is constrained by this document from adducing expert evidence which repeats, expands on or is inconsistent with the matters set out herein.

4. This document is composed of the following sections:

   A. Overview of the combustion process in diesel engines

B. Products of the combustion process

C. Relevant Components

D. Engine Control Units

E. On Board Diagnostics Systems

F. Type-Approval Testing Procedure

Appendix A: Summary of the Emissions Control System on each Sample Vehicle

A. Overview of the combustion process in diesel engines

5. Diesel engines are powered by the combustion of diesel fuel. Diesel engines operate by compressing inlet air in the combustion chamber, causing it to reach such a high temperature that, when the diesel fuel is injected, the air-fuel mixture should auto-ignite in a spontaneous reaction. The combustion releases the energy which drives the pistons, creating the mechanical force that powers the vehicle. The operating cycle in diesel engines generally follows the following (simplified) sequence:

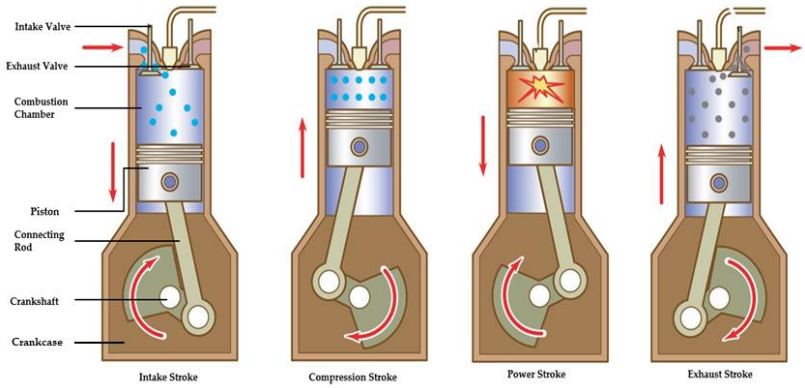


Figure 1: The four-stroke operating cycle in diesel engines[1]

[1] *Encyclopaedia Britannica*, 'Four-Stroke Cycle' <link> accessed 21 October 2024.

a. **Intake Stroke**[2]: The piston moves down the cylinder and the intake valves open allowing intake gas mixture[3] to enter the combustion chamber. The exhaust valves remain closed during this stroke.

b. **Compression Stroke**: Both the intake and exhaust valves are closed during this stroke. The piston moves back up the cylinder and the trapped mass of gas is compressed. This compression results in an increase in the temperature of the trapped mass of air.

c. **Power Stroke**: As the piston approaches the top of its stroke (referred to as top dead centre or "**TDC**"), diesel fuel is injected (sprayed) at high pressure into the combustion chamber by the fuel injector. The injection of diesel fuel can take place just before the TDC (a more "**advanced**" injection timing) or after the TDC (a more "**retarded**" injection timing[4]). The injection of diesel fuel into the compressed and hot air in the combustion chamber causes the fuel to combust. This combustion results in an increase in the gas temperature, generating pressure which forces the piston down and generates mechanical force which is transmitted to the powertrain via the crankshaft.

d. **Exhaust Stroke**: The exhaust valve opens, and the returning piston forces the burnt gases out of the combustion chamber through the exhaust valve. The intake valve remains closed during this stroke.

B. <u>Products of the combustion process</u>

6. When fuel burns in the combustion chamber, products of combustion are created. In "ideal" complete combustion, the hydrocarbon molecules in the diesel fuel are fully oxidised to carbon dioxide and water vapour:

Hydrocarbon + Oxygen → Carbon dioxide + Water vapour:

$$C_nH_{2n+2} + O_2 \rightarrow CO_2 + H_2O$$

Or as a balanced chemical equation[5]:

$$2C_nH_{2n+2} + (3n+1)O_2 \rightarrow 2nCO_2 + (2n+2)H_2O$$

---

[2] When the piston moves from the top of its range of motion to the bottom of its range of motion (and vice versa) this is a "stroke". There are 4 strokes in the operating cycle commonly used in passenger car engines; hence it is known as the 4-stroke cycle.

[3] Intake gas mixture (defined as air and recirculated exhaust gases) can be introduced into the cylinder during the intake stroke.

[4] This is discussed in further detail at paragraph 49 below.

[5] This equation is idealised. Diesel fuel contains more complex hydrocarbons and in practice some more complex reactions may occur.

7. However, air consists of 78% nitrogen and 21% oxygen, along with varying levels of water vapour. Other elements can enter the combustion chamber, e.g. from lubricating oil and its additives, and impurities in the fuel such as sulphur. Furthermore, the conditions in the combustion chamber vary widely both spatially within the chamber and temporally throughout the combustion process, hence ideal combustion of all the fuel in the short time available is not possible. Products of the combustion process (collectively referred to as "**Combustion Products**") include:

   a. **Carbon Dioxide** ("**CO_2**"): this is produced as a result of the combustion of the carbon atoms found in diesel fuel with oxygen.

   b. **Water** ("**H_2O**"): the other main combustion product is water as a reaction of hydrogen with oxygen.

   c. **Carbon Monoxide** ("**CO**"): generally produced as a result of incomplete combustion of the injected fuel to carbon dioxide (CO_2). CO is in any event also produced in the cylinder due to individual reactions of CO formation and decomposition that take place naturally.

   d. **Hydrocarbons** ("**HC**"): is a generic designation for a range of chemical compounds composed predominantly of carbon and hydrogen. HC in the exhaust is unburned fuel resulting from incomplete combustion. Hydrocarbons are also produced by entrained lubrication oil constituents.

   e. **Nitrogen Oxides** ("**NOx**"): is the collective term for the chemical compounds produced from the reaction between nitrogen and oxygen during fuel combustion. NOx primarily comprises nitric oxide ("**NO**") and Nitrogen Dioxide ("**NO_2**"). NOx is created in the combustion chamber by the reaction of nitrogen with oxygen at high pressure and high temperature. Generally, higher levels of NOx are produced when there is greater oxygen concentration and high pressure and higher temperature.

   f. **Particulate Matter** ("**PM**"): refers to a mixture of small solid particles and liquid droplets (some of which will adhere to the solid soot particles). PM generally consists of solid carbon, organic compounds, inorganic compounds, and metal particles. As with HC and CO, the carbonaceous fraction of PM is generally produced from incomplete combustion.

   g. **Other Combustion Products are generated such as Sulphur Dioxide** ("**SO_2**"): which is the primary sulphurous compound produced during the combustion process from the small amounts of sulphur present in diesel fuel and in engine lubricating oil.

Figure 2 below shows an indicative composition of exhaust gas from a diesel engine:

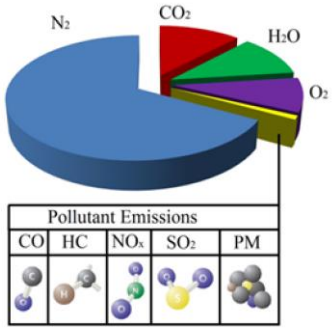


Figure 2: Indicative composition of exhaust gas from a diesel engine

8. The most abundant component in the exhaust gas is nitrogen N_2, coming from the air introduced in the combustion chamber, which is not directly involved in the combustion process, except for the tendency of N_2 to oxidise at high temperatures to form NOx.

9. The combustion process also has physical effects on the vehicle's behaviour. For instance, the combustion process creates noise and may lead to vibrations.

Combustion Trade-offs: Air-to-Fuel Ratio, pressure and temperature

10. The efficiency of the combustion and the relative proportions of the Combustion Products will depend on:

    a. The Air-to-Fuel Ratio ("**AFR**"). When the AFR matches exactly the ratio required for complete combustion, and there is neither excess fuel nor excess air, this is the stoichiometric (or chemically correct) ratio. The overall AFR (or "*bulk AFR*") is the ratio of *all of the air* in the combustion chamber before combustion, and *all of the fuel* that will be injected into the combustion chamber in the current cycle. However, the "*local AFR*" (the AFR at any particular time and place in the combustion chamber), will vary widely, due to the heterogenous nature of the Air-Fuel mixture. Other things being equal, the degree of mixing in the combustion chamber of the fuel (droplets and vapour) with the intake gases influences the relative amounts and composition of the Combustion Products.

    b. When the AFR is greater than the stoichiometric AFR, there is more air (oxygen) than is needed for complete combustion and the engine is said to be running on a 'lean mixture.' Conversely, a 'rich mixture' is one with an AFR less than the stoichiometric ratio, so excess fuel / insufficient air (oxygen) is present to support complete combustion. Diesel engines generally operate with a bulk AFR leaner than the stoichiometric AFR. However, it should be noted that local conditions across the combustion chamber influence the Combustion Products.

c. The pressure of the fresh air being fed to the combustion chamber depends on the turbocharger (see paragraph 57.c). The output pressure of the turbocharger's compressor depends on the exhaust flow driving the turbocharger's turbine. The outlet of the turbocharger's compressor is connected to the intake of the combustion chambers. The higher the output pressure from the turbocharger's compressor, the higher the pressure will be in the intake of the combustion chambers, so the higher the pressure will be when the fuel is injected and the more easily the fuel will auto-ignite.

d. The temperature of the intake gases depends on several factors, including but not limited to:

   i. the ambient temperature;

   ii. air humidity;

   iii. the increase in the temperature of the fresh air when it is compressed by the turbocharger compressor and the decrease in temperature when it is then passed through a heat exchanger ("**Charge Air Cooler**", see paragraph 57.d) to cool it;

   iv. the temperature and quantity of Exhaust Gas Recirculation ("**EGR**") gases being mixed into the intake air (EGR is explained in further detail in section C.1.A Exhaust Gas Recirculation Systems below); and

   v. the engine temperature.

11. Diesel engine emissions are affected by the local conditions including AFR, temperature and pressure at the points of combustion across the combustion chamber. For example, higher local temperatures and oxygen availability tend to result in more complete combustion and consequently reduced emissions of CO, HC, and PM. However, the trade-off is that the higher combustion temperatures and oxygen concentration can lead to an increase in NOx, which is formed more readily at elevated temperatures.

Diesel Engine Control Units ("**ECUs**") control the combustion events under a wide range of operating conditions, considering, *inter alia*, the engine speed and load[6] based on the demands of the driver, the temperature of the engine as it warms up, and the ambient conditions. The three conditions listed above (AFR, pressure and temperature) influence the combustion and emission formation. The software and calibration (see section D) of the ECU dynamically sets, *inter alia*, combinations of diesel fuel injection settings, EGR rates, and turbocharger settings, which are required to control these three conditions varying operating conditions vary.

12. Whilst all the calibration settings can have a significant effect on the combustion conditions and hence the emissions at the outlet of the combustion chamber, the EGR rate is one of the most significant factors for the reasons set out in in paragraph 18. Examples of emissions trade-offs in response to EGR rate are shown in Figure 3 below:

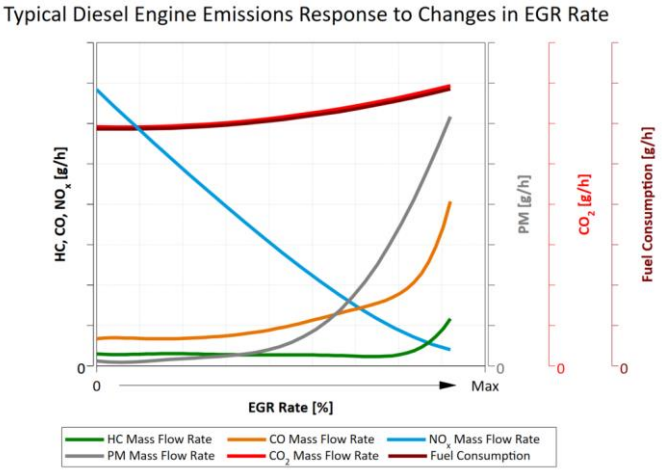


Figure 3: Typical diesel engine emissions at the outlet of the combustion chamber in response to changes in EGR rate

13. As shown in Figure 3, typical diesel engine emissions at the outlet of the combustion chamber in response to changes in EGR rate are one of the key trade-offs that must be managed in diesel engines is the NOx vs PM trade-off. Although EGR can be highly effective at reducing NOx emissions at the outlet of the combustion chamber, this can come at the expense of significant increases in PM emissions (as well as HC and CO) which have to be managed.

C. <u>Relevant Components</u>

[6] Engine load is used interchangeably with torque in the context of combustion engines. The torque or load demand is directly controlled by the driver via the accelerator pedal which is translated into a torque request within the ECU which in turn defines the injected fuel quantity.

14. This section considers and provides an overview of the components commonly used in vehicles with diesel engines. Some of these systems and components are found across many of the Sample Vehicles, whereas others may only be found in few of the Sample Vehicles. The descriptions of these systems and components are intended to be general as the particulars of systems and components between vehicle models and makes may differ. Appendix A provides a list of Sample Vehicles by reference to the systems, components, and configurations considered in this section.

15. The components commonly used in diesel engines, including the ECS, constantly interact throughout the engine operation. The addition of new components affects the operation of those historically present in the engine, generating constraints unknown at the time of their first designing.

16. A diesel engine's Exhaust Aftertreatment System ("**EATS**") is generally defined as the emissions control components in the exhaust line after the turbocharger but before the silencer/muffler. The EATS can have a significant effect on the tailpipe emissions by reducing the pollutant levels from the exhaust gas at the outlet of the combustion chamber. The effectiveness of the EATS is dependent on a number of factors, including but not limited to the concentrations of pollutants in the exhaust gases at the outlet of the combustion chamber, the flow-rate of exhaust gas through the EATS components and the temperature of the exhaust gas and the EATS components. EATS components may be combined together or be configured individually. The order of the components along the exhaust stream is important to the overall functionality. These devices typically include some of the following[7]:

    a. **Lean NOx Trap ("LNT")**: a catalytic device which converts (or reduces) NOx into water (H_2O) and nitrogen (N_2) by means of a series of chemical reactions catalysed by precious metals (see paragraphs 28 to 32 below);

    b. **Selective Catalytic Reduction ("SCR")**: a type of catalytic converter which converts (or reduces) NOx into water (H_2O) and nitrogen (N_2) by the chemical reaction of NOx with a reducing agent, typically ammonia (NH_3) in the presence of a catalyst (see paragraphs 33 to 45 below);

    c. **Diesel Oxidation Catalyst ("DOC")**: a device that converts, through oxidation CO, HC and some PM into water vapor and CO_2 (see paragraphs 51 to 52 below); and

    d. **Diesel Particulate Filter ("DPF")**: a device designed to remove PM from the exhaust gas of a diesel engine (see paragraphs 47 to 50 below).

C.1.A Exhaust Gas Recirculation Systems

[7] The devices are not necessarily listed in the order that they would appear in the EATS.

17. Exhaust Gas Recirculation ("**EGR**") systems are integrated into diesel engines to support the control of NOx emissions.

18. Recirculating exhaust gases into the combustion chamber generally results in lower oxygen concentrations and an increase in the specific heat[8] of the combustion gases, leading to lower combustion temperatures and thus lower NOx. The use of EGR generally leads to lower engine efficiency (i.e. fuel economy), and higher CO_2, CO, HC, and PM emissions.

19. EGR systems recirculate exhaust gases back into the combustion chamber, and are designed to decrease the formation of NOx in the combustion cylinders. The functioning of the EGR system is primarily regulated by changing the position of the EGR valve(s). As far as the valve is open, exhaust gases can pass through it enabling the recirculation of the exhaust gases into the engine's air intake. The degree of opening of an EGR valve can be adjusted to allow more or less exhaust gases to be recirculated.

20. "**EGR Rate**" refers to the amount of recirculated exhaust gas inducted into the cylinders relative to the total charge air flow (i.e. the sum of fresh air and recirculated exhaust gas) and is commonly stated as a percentage.

21. An **EGR valve** is typically an electro-mechanical component that controls EGR flow. The position of the EGR valve regulates the flow of recirculated exhaust gas entering the combustion chamber. The physical form of EGR valves varies between engines. Common forms include a poppet style valve and a rotary style valve.

Figure 4: An example of an EGR valve adopting a poppet style design[9]

22. Typically, the EGR Rate continuously changes throughout normal vehicle operation and use and depends on numerous interrelated calibrated values. The EGR Rate cannot directly be inferred from the EGR valve position: an EGR valve which is 100%

[8] The specific heat capacity is the energy required to increase the temperature of 1kg of substance by 1°C (strictly speaking, by 1K, which is the same temperature interval as 1°C).
[9] EGR Systems & Components, Figure 13, DieselNet.

open may still result in (for example) an EGR Rate of only 50% as the EGR Rate is impacted by other parameters, in particular components that influence the air flow and pressures in the engine. In some vehicles the EGR rate may be set by reference to mass air flow ("**MAF**").[10] A vehicle has a MAF sensor which monitors the MAF into the engine's air intake. The ECU determines the desired mass air flow set point ("**MAFSP**"), and aims to achieve this value as closely as possible by modulating the EGR valve position. A lower MAFSP results in the EGR rate being increased; a higher MASFP results in the EGR rate being decreased.

23. As noted above, all else being equal, a higher EGR Rate lowers oxygen concentrations and increases the heat capacity of the gases in the combustion chamber, leading to lower temperatures of the gases in the combustion chamber and thus lower NOx. Generally, but depending on operating circumstances, at these lower peak temperatures and oxygen concentrations, less NOx is formed but at the same time, due to a corresponding lack of oxygen mass/concentration, more PM (as well as potentially CO and HC) is formed and there is lower fuel economy and higher CO_2 emissions.

24. On the other hand, all else being equal, a lower EGR Rate means that there is more fresh air in the combustion chamber. This increases the oxygen concentration and temperature in the combustion chamber, generally leading to the formation of more NOx and lower PM (and potentially HC, CO_2 and CO). Even though a vehicle may be fitted with a DPF, control of PM emissions is important to minimise DPF loading and the need for active regenerations (which in turn increase NOx, decrease fuel economy and increase CO_2 emissions).

25. EGR Systems can take various configurations. Generally, there are multiple common EGR paths: (a) a HP-EGR; (b) a LP-EGR; and (c) a Dual-Loop EGR system ("**DL-EGR**"):

    a. **HP-EGR** directs Combustion Products from the exhaust manifold, at a position upstream of the turbine, to the intake manifold. In a simplified air-flow diagram, an HP-EGR looks like this:

[10] The EGR Rate may be set/controlled directly or through other parameters including the MAFSP.

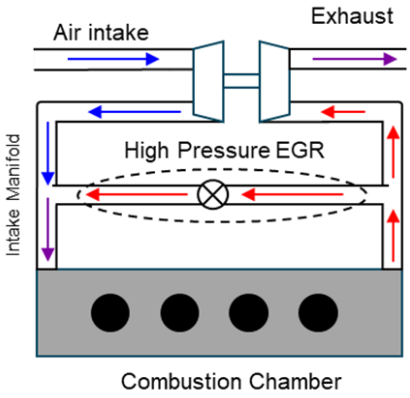
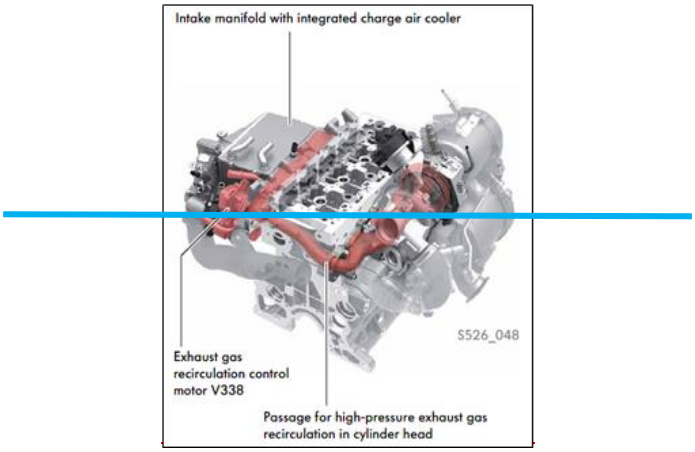


Figure 5: Schematic of an HP-EGR system. This and following diagrams are simplified schematics which exclude multiple components of the air path. Note that the position of the EGR Closing Mechanisms, symbolized here as an EGR Valve ⊗, may vary to be either before or after the EGR Cooler (if present).



b. **LP-EGR** generally involves an EGR circuit being placed after the turbocharger turbine and sometimes also after at least some of the after-treatment systems (usually downstream of the DPF). It directs the exhaust gas from the turbocharger turbine to the turbocharger's intake, where the pressure is lower. In a simplified air-flow diagram, a LP-EGR system looks like this:

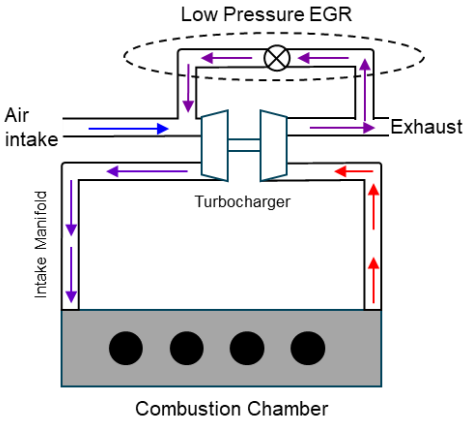
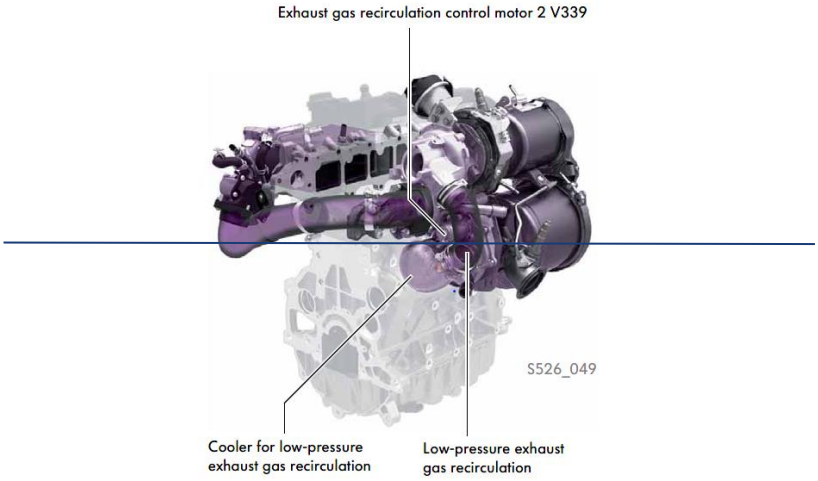
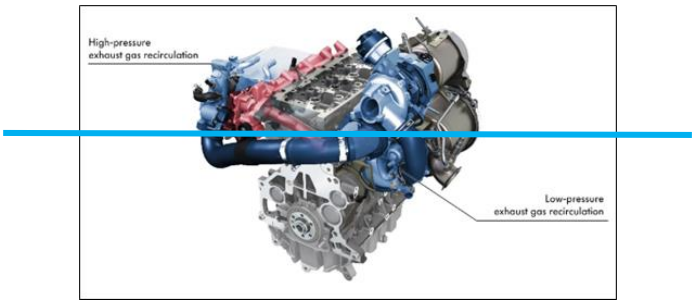
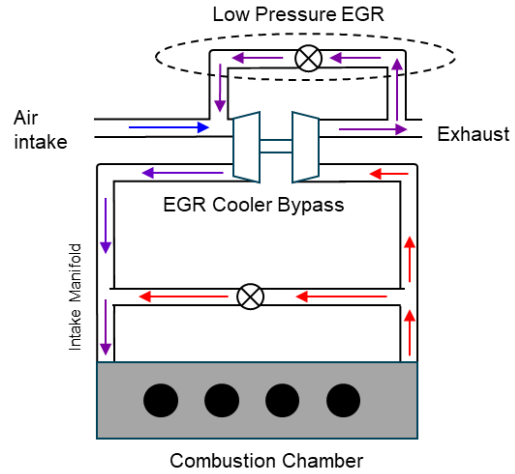


Figure 6: Schematic of an LP-EGR system



c. **DL-EGR** generally involves the use of both a HP-EGR and LP-EGR.





26. Each of the above configurations can be cooled or uncooled:

a. **Uncooled EGR** (as shown in the diagrams above) does not involve the use of an EGR Cooler.

b. **Cooled EGR** features an EGR Cooler: a heat exchanger which reduces the temperature of exhaust gas passing through it to increase the mass of recirculated exhaust gas and air, and decrease the temperature of the mixture of the gases, that enter the combustion chamber (by virtue of the higher density of cooler gas). Cooler recirculated exhaust gas also contributes to avoiding the exceedance of the upper limits for temperature of the intake system. All else being equal, cooling of the recirculated exhaust gas leads to a lower rate of NOx formation (and potentially a better NOx-PM trade-off) in the cylinder. The exact position of the EGR Cooler varies between vehicles.

i. The following diagram shows this principle with a HP-EGR system:

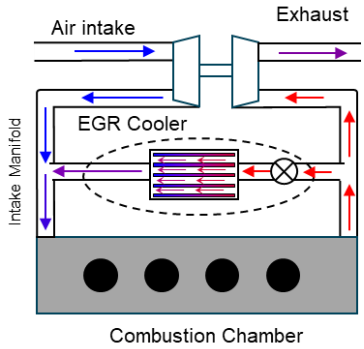


Figure 7: Schematic of a Cooled HP EGR system

ii. An engine may have an HP-EGR cooler and/or an LP-EGR cooler or be un-cooled. All EGR Coolers use engine coolant, however the physical form and design of EGR Coolers varies between engines. In a DL-EGR, either the HP-EGR or the LP-EGR (or both) may be cooled (i.e. there might be use of cooled or un-cooled HP-EGR or LP-EGR in different ambient temperature conditions).

Figure 8: An example of a tubular EGR cooler[11]

[11] Sahaya Surendira Babu, P., Kumar, P. (2020). External Exhaust Gas Recirculation. In: Lakshminarayanan, P., Agarwal, A. (eds) Design and Development of Heavy Duty Diesel Engines. Energy, Environment, and Sustainability. Springer, Singapore.

Figure 9: An example of a compact 'horseshoe' EGR cooler[12]

c. **EGR cooler bypass**: the EGR system may be set up to include both an EGR Cooler and an EGR Cooler bypass with a bypass valve or flap, giving the option of running cooled or uncooled EGR to suit different engine operation conditions. Among other things, this enables better control of HC and CO emissions, particularly during engine-warm-up. The following graphic shows an EGR cooler bypass of an HP EGR and Figure 11 shows a typical EGR Cooler with integrated bypass passage:

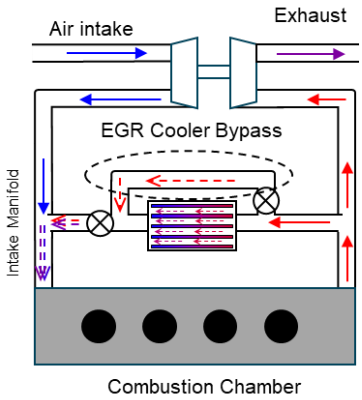


Figure 10: Schematic of an HP EGR system with EGR cooler bypass

[12] EGR Systems & Components, Figure 23, DieselNet.

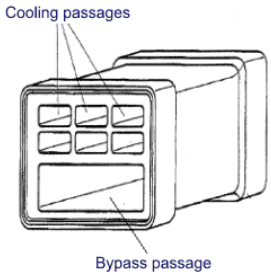


Figure 11: An example of an EGR cooler core with integrated bypass passage[13]

27. Each EGR path requires a corresponding control strategy within the engine management system.

C.1.B NOx Aftertreatment Systems

i. Lean NOx Trap / NOx Storage Catalyst

28. A NOx Storage Catalyst or Lean NOx Trap ("**LNT**") is a type of device which reduces NOx into water (H_2O) and nitrogen (N_2) catalysed by precious metals. Generally, an LNT Catalyst consists of precious metals, a storage medium, and a high surface area support material typically comprised of a honeycomb ceramic substrate which provides a large surface area for the precious metals and storage elements to disperse on (maximising the contact between the exhaust gases and the catalytic components).

29. The LNT system operates in a two-stage cycle by:

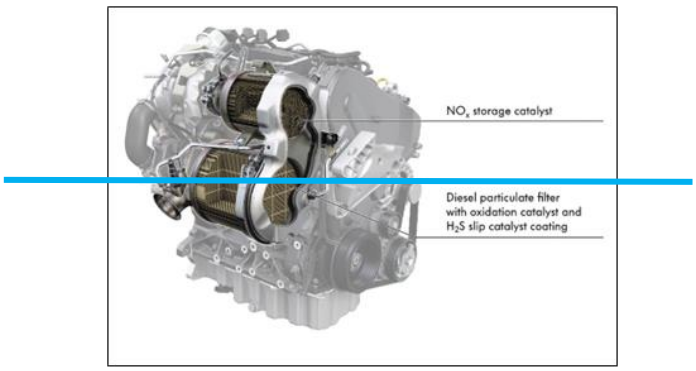
    a. Collecting NOx emissions within a catalyst (the "**LNT Catalyst**") when the engine is running on a lean mixture (the **"Loading Phase"**) by oxidation of NO to NO_2, catalysed by precious metals on the surface of the support material, and by adsorption of NO_2 onto the storage element. The operation and effectiveness of the NOx adsorption depends on the exhaust temperature. Generally, there is a range of operating temperatures within which the LNT Catalyst is effective for NOx adsorption. Above a certain temperature, an LNT Catalyst can no longer store NOx. An LNT Catalyst has limited capacity as it has a finite surface area and adsorption sites for NOx. As more NOx is adsorbed by the catalyst, it becomes saturated and its ability to continue adsorbing NOx is reduced. Both the temperature range and the maximum amount of NOx that can be stored reduce as the LNT ages. The duration of the Loading Phase varies and is of the order of 30 seconds to a few minutes.

    b. Through an active regeneration process, NOx stored in the LNT Catalyst is converted or purged (the "**Purging Phase**") which involves a periodic "rich

[13] EGR Systems & Components, Figure 26, DieselNet.

spike" mode under ECU control to allow the conversion of the stored NOx. When running a rich mixture, HC and CO – the chemical byproducts from the combustion chamber – react with the stored NOx to reduce it to nitrogen (N_2) and other byproducts including CO_2 and H_2O (carbon dioxide and water). The LNT requires control of the engine combustion parameters to switch from the normal, lean operation of the diesel engine to this "rich spike" mode. The engine control methodology and calibration must be developed so as to ensure that where a controlled rich spike is triggered, which is different from normal lean operating conditions, that is transparent to the driver.

30. The LNT is a "continuously regenerating" system as far as the relevant regulations are concerned, meaning that LNT purging occurs frequently enough such that it is always included in the certification test cycles and does not need to be accounted for in the same way as DPF regeneration (see paragraph 50 below).



31. Effective conversion of NOx during the Purging Phase requires both adjusting the AFR to achieve the necessary rich conditions and also holding the LNT temperature within a certain range for several seconds. The Purging Phase is only possible when the LNT Catalyst and engine have reached a sufficiently high operating temperature and when the driver demand is relatively stable.

32. The LNT efficiency reduces due to build up of sulphur oxides ("**SOx**") on the catalyst surface. The SOx results from the oxidisation of the sulphur that is found in the fuel and lubricating oil. To maintain efficiency, the LNT must undergo a periodic removal of SOx ("**DeSOx**") phase which involves running in a rich mode at very high exhaust temperature.

ii. Selective Catalytic Reduction System

33. A Selective Catalytic Reduction ("**SCR**") system is a type of catalytic converter which reduces NOx into water (H_2O) and nitrogen (N_2) using a chemical reaction of NOx with a reducing agent, typically ammonia (NH_3).

34. The reducing agent can be obtained by injecting or dosing into the exhaust stream an ammonia precursor such as Diesel Exhaust Fluid ("**DEF**") (also commercially known as "**AdBlue**") consisting of a urea-water solution.

35. Components within the SCR system

a. The **SCR Catalyst** is where the chemical reactions occur in the SCR process. It contains the reduction catalyst which is necessary for this reaction to occur and typically uses a coated substrate. The precise SCR Catalyst used will vary between vehicles.

b. DEF is stored in a tank (the "**DEF Storage Tank**") which is typically located in close physical proximity to the diesel fuel tank. DEF is pumped from the DEF Storage Tank to the dosing module(s) before passing through a mixer and onto the SCR Catalyst.

c. The **DEF dosing module** (which may also be called an AdBlue or SCR dosing module, or AdBlue or SCR doser) uses an injection nozzle to inject DEF onto the SCR Catalyst via the mixer. There is variation between vehicles in terms of the design and number of DEF dosing modules. Vehicles with more than one SCR Catalyst may have more than one DEF dosing module.

d. The proximity of the dosing module to other components is contingent on the overall SCR system design. Dosing modules for close-coupled SCR Catalysts will typically be in closer physical proximity to the cylinders. Dosing modules for underfloor SCRs will typically be in an underfloor location.

e. The **DEF mixer** is a component (which varies in design) positioned between the SCR dosing module and the SCR Catalyst. Exhaust gas and DEF mix in the mixer, which aims to create a homogeneous mixture of DEF and exhaust gas to maximise urea decomposition and ensure that NH_3 arrives near-uniformly distributed in the exhaust across the face of the SCR Catalyst. There is variation between vehicles in terms of the hardware of the DEF mixer, and how many DEF mixers there are in vehicles with more than one SCR Catalyst.

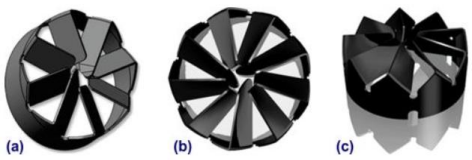


Figure 12: Examples of DEF mixers for light-duty applications[14]

[14] Urea Dosing and Injection Systems, Figure 12, DieselNet.

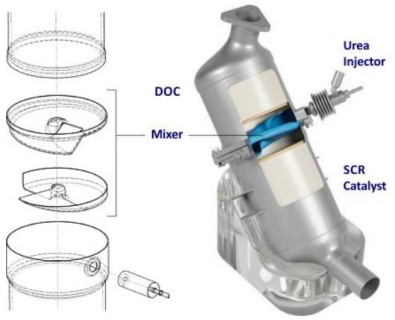


Figure 13: An example compact mixer installed between DOC and SCR Catalyst[15]

36. A passive SCR system ("**P-SCR**") does not have its own dosing system and instead utilises ammonia that can be produced in small quantities in the exhaust flow by chemical reactions occurring in other aftertreatment components placed upstream, such as an actively-dosed SCR, or an LNT which may produce ammonia during purge mode.

37. In an active SCR system that involves injection of DEF into the exhaust stream, the DEF decomposes in the hot exhaust gases and on the SCR catalyst surface, generating the ammonia (NH_3) required for the NOx reduction to take place. The ammonia is adsorbed onto the surfaces of the SCR Catalyst and reacts on the catalyst surfaces with NOx converting the NOx into nitrogen (N_2) and water vapour (H_2O).

38. Both reactions (decomposition of DEF and NOx reduction) require minimum temperatures (albeit the latter reaction can take place using existing ammonia stored on the catalyst derived from previous dosages of DEF). It is therefore only possible to inject DEF when the necessary temperature is reached for the decomposition reaction to take place.

39. The amount of ammonia that can be stored by the SCR Catalyst (so-called "**Ammonia Storage Capacity**") is dependent (amongst other things) on temperatures in the catalyst. For example, when a vehicle is first started, the SCR Catalyst starts at a relatively low temperature and increases to reach a temperature range which allows for the necessary chemical reactions to take place for reducing NOx emissions (the so-called "light-off temperature"). At a certain temperature above the minimum temperature[16] for the decomposition reaction, the Ammonia Storage Capacity starts to reduce. The quantity of DEF injection must take into account (amongst other things) the amount of NOx currently in the exhaust stream, the amount of ammonia stored on the SCR Catalyst, and the SCR Catalyst's current storage capacity.

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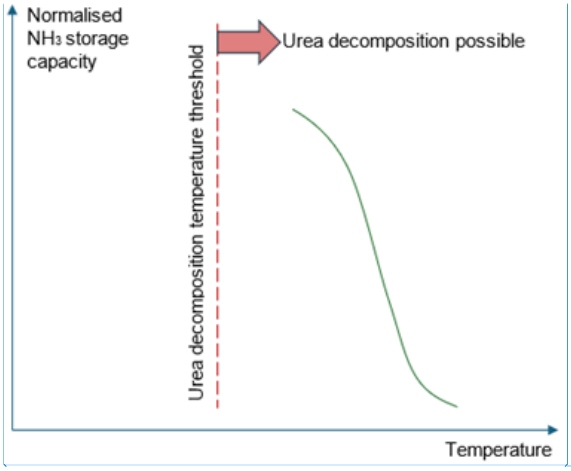
[15] Urea Dosing and Injection Systems, Figure 14, DieselNet.

[16] Reduction of the Ammonia Storage Capacity might also start before reaching the minimum temperature for the decomposition reaction depending on the design of the SCR system.



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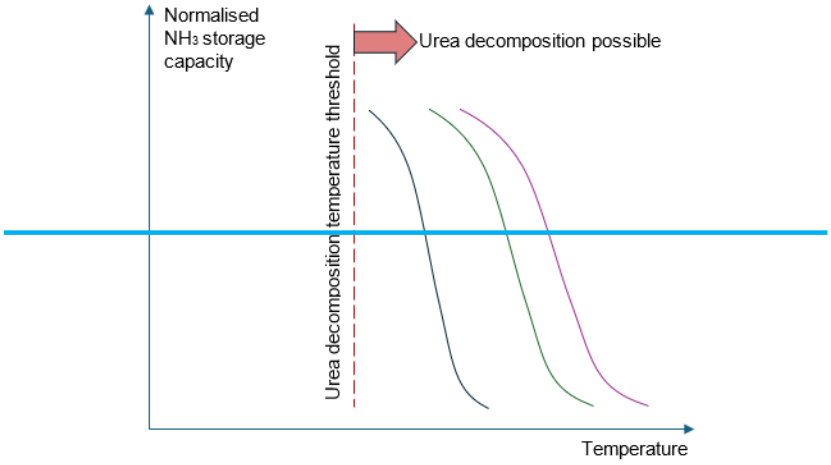


40. The reaction behaviour in the SCR Catalyst is influenced by a variety of interdependent factors, including, *inter alia*:

a. **The substrate and chemical make-up of the catalyst washcoat.**

b. **The size and shape of the SCR Catalyst** – while a larger catalyst provides more surface area for reactions, it will also have higher thermal inertia (essentially, a measure of the rate at which a material's temperature changes to match the temperature of its surroundings – which depends on various factors) and therefore take longer to warm up.

c. **The exhaust gas temperature, which is a significant factor impacting the temperature of the SCR system**.

d. **The exhaust gas composition (e.g. NO:NO2 ratio).**

e. **The placement of the SCR relative to the combustion chamber** - exhaust gas temperatures are lower where the SCR is further away from the combustion chamber.

f. **The temperature of the DEF** sprayed into the exhaust stream.

g. **Ambient temperature,** which affects the temperature of the exhaust and the SCR system.

h. **Engine temperature,** which affects the temperature of the exhaust and the SCR system.

i. **The engine load and speed** – this primarily influences the exhaust gas temperature, the exhaust gas flow rate and the NOx flow rate.

j. **Exhaust gas flow rate and residence time** – the rate at which exhaust gases flow through the SCR Catalyst can affect the temperature distribution within the catalyst and therefore the efficiency of NOx conversion. Higher flow rates reduce the time which the gases spend inside the catalyst, potentially leading to less effective NOx conversion. Conversely, lower flow rates allow more time for the reaction and therefore potentially higher overall NOx conversion.

k. **EGR Rate –** as indicated above, EGR Rate influences exhaust gas temperatures and NOx concentrations in the exhaust.

l. **Catalyst aging and degradation** – the performance of the SCR Catalyst can be reduced by aging and degradation. Aging occurs due to thermal cycling over the operating lifetime of the SCR Catalyst, and other factors. A degraded catalyst does not perform as efficiently.

m. **The blockage of reactive material** in the SCR Catalyst by Hydrocarbons.

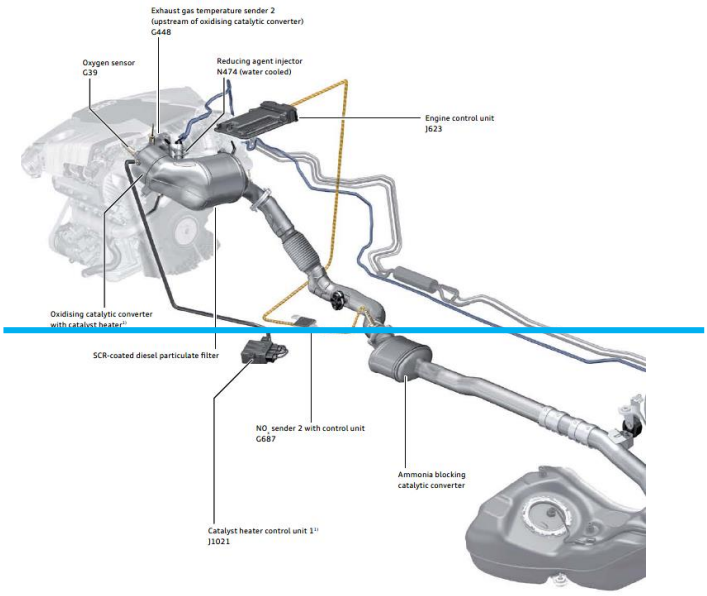
n. **After-treatment system integration** – the integration of the SCR Catalyst into the exhaust system, particularly the location of the SCR catalyst relative to the other aftertreatment components. This influences the composition of the exhaust gases entering into the SCR Catalyst.

41. The amount of DEF consumed in an SCR System is influenced by the dosing strategy, which determines how much and how often DEF is injected into the exhaust stream. NOx sensors may be fitted upstream and/or downstream of the SCR Catalyst which help to inform the dosing strategy. A DEF dosing strategy uses further modelled and measured values as indicators of the amount of ammonia stored and likely NOx conversion and adjusts DEF dosing based on these models and other factors influencing the NOx conversion efficiency behaviour. A DEF dosing strategy may incorporate a target NOx conversion efficiency rate.

42. DEF underdosing can lead to ineffective NOx reduction, as insufficient ammonia is available to react with the NOx in the exhaust, causing higher tailpipe NOx emissions.

43. DEF overdosing leads to excess ammonia which may pass through the SCR Catalyst and be emitted via the tailpipe (known as "**Ammonia Slip**"). Ammonia Slip has to be minimized as ammonia is a toxic pollutant which is hazardous to human health and the environment. DEF overdosing may also cause damage to the SCR system and/or reduced NOx conversion efficiency.

44. In some vehicles, an SCR Catalyst is incorporated into a diesel particulate filter ("**DPF**") as an S-DPF (also called SCRF, SCRoF, SCRonDPF, SDPF and FSCR). This is achieved by applying an SCR catalyst washcoat over the DPF substrate or a particular zone of it. The substrate/catalyst system is more complex in systems with an S-DPF, as the two functions of the SCR Catalyst and the DPF are combined.



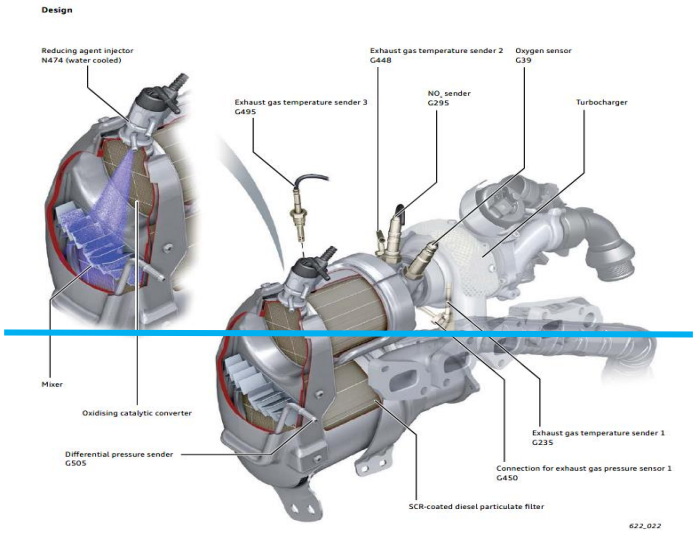


Figure 14: An example 3D diagram of an S-DPF[17]

45. The configuration and location of SCR Catalyst(s) within an SCR system varies. Some light duty diesel vehicles have a close-coupled SCR in close proximity to the combustion cylinder, whereas other vehicles have the SCR Catalyst mounted underfloor.

C.2 Relevant non-NOx control components

46. The actual emissions of the vehicle of combustion products other than NOx are controlled by further aftertreatment devices. These may interplay with the directly NOx-relevant components of the ECS.

i. Diesel Particulate Filter

47. A DPF is a device designed to significantly decrease PM in the exhaust gas of a diesel engine before it is emitted from the tailpipe. All modern light duty diesel vehicles contain a DPF together with any of the NOx reduction technology combinations described elsewhere in this document.

48. Commonly, a DPF has a catalytic coating and consists of a filter which is usually made of a ceramic material with a honeycomb structure. Alternate channels on the inlet and outlet of the honeycomb structure force exhaust gases (which contain PM) through the channel walls, allowing exhaust gases to pass through while trapping PM within and on the channel walls and filtering them from the exhaust stream.

[17] VW Group engine.

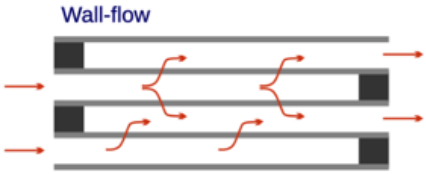
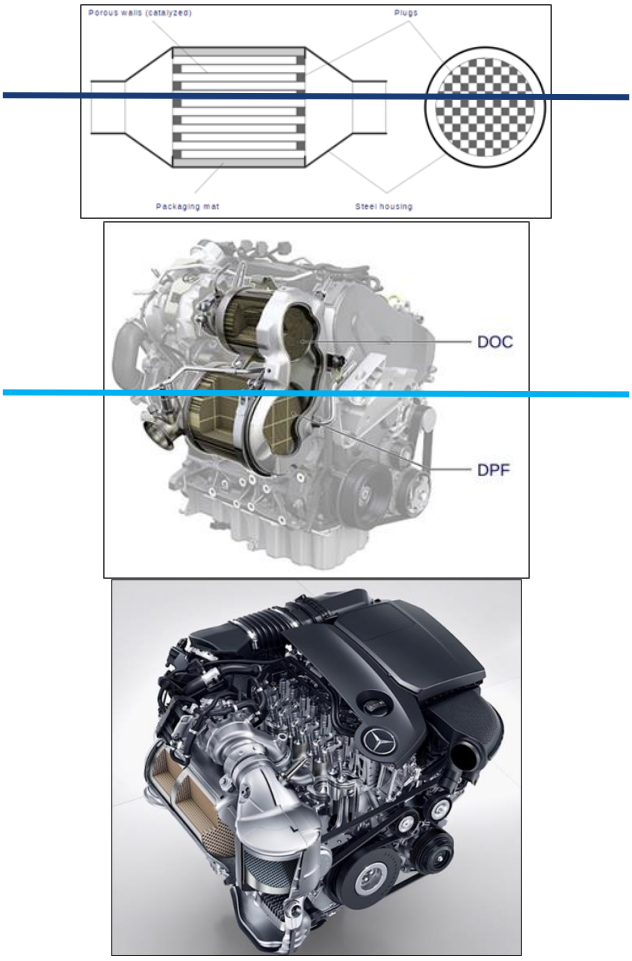


Figure 15: DPF Filter Walls[18]



[18] DieselNet, 'Diesel Particulate Filters (DPF)' < accessed 21 October 2024.

Figure 16: An example location of a DPF[19]

49. All DPFs have a finite capacity for capturing and storing PM. It is part of the design and expected operation of vehicles with a DPF that over time through use of the vehicle, the trapped particles will accumulate. This can lead to increased backpressure[20] with consequential impacts on engine behaviour (e.g. increased fuel consumption/CO_2 emissions). In order to control the mass of PM accumulated in the DPF and therefore prevent the backpressure becoming excessive, the stored PM must be removed through "regeneration". Two regeneration processes can take place within the DPF as described below – passive and active:

    a. **Passive Regeneration:** in this process, NO_2 formed (from NO emissions from the combustion chamber) in the DOC or a catalyst coating on the DPF itself (or both), react by oxidising PM to CO_2, which then exits through the DPF. Additionally, some NO_2 is produced directly in the combustion chamber along with NO. This process by which the PM is oxidised to CO_2 occurs naturally without engine management system intervention and is most effective at exhaust gas temperatures between approximately 250-400°C. The net rate of PM removal or accumulation in the DPF which occurs during the passive regeneration process depends on engine speed and load (which in turn depend on vehicle operational characteristics, including driving style), NO_2 and PM concentrations at the inlet to the DPF, and exhaust gas temperature. Passive regeneration is a continuous process (where the PM in the DPF is continuously oxidised) that occurs any time there is available NO_2 in the active temperature range of the DPF.

    b. **Active Regeneration**: in this process, engine parameters are changed so the engine operates in a manner that increases the exhaust gas temperature entering the DPF, typically between around 550-650°C (although DPF regeneration can be facilitated using a fuel borne catalyst, allowing PM to oxidise at a lower temperature ~500°C), which is necessary for the PM trapped in the DPF to oxidise directly with oxygen in the exhaust gas. This is typically achieved by retarding injection timing[21] and throttling the engine intake.[22]

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[19] Mercedes-Benz OM654 engine introduced in 2016, news: Mercedes-Benz unveils the new OM 654 2.0 liter diesel engine, Dieselnet. This diagram is not representative of the DPF in all vehicles.

[20] The resistance against the flow of exhaust gases as they pass through the filter, which results in increased pumping losses in the engine, as the piston pushes out the exhaust gas against the back pressure.

[21] Retarding injection timing during active regeneration means injecting fuel later in the engine's combustion stroke. This results in higher exhaust gas temperatures.

[22] Throttling the engine intake during active regeneration involves partially closing a throttle to limit the amount of air entering the combustion chamber. This reduction in airflow causes the engine to run with a less lean fuel mixture and reduced air mass flow, leading to higher exhaust temperatures. The increased heat is essential for effectively burning off the PM accumulated in the DPF during the regeneration process.

Furthermore, a late post injection in the combustion chamber may be used in order to generate a temperature increase (known as exotherm) across the DOC, and thus reach the appropriate exhaust temperature upstream of the DPF, to enable the regeneration. Alternatively, a fuel injector may be used upstream of the DOC to directly inject fuel into the exhaust system.[23] Active regeneration is triggered by the Engine Electronic Control Unit depending on a wide range of factors, including the estimated load of PM in the DPF (which may take into account whether passive regeneration has occurred) and engine operating conditions. One method to calculate the load of PM in a DPF is to use a combination of modelling of loading and measurement of the pressure drop across the DPF. While passive regeneration is more dependent on vehicle operational characteristics, NO_2 formation rates, PM emission rates, and exhaust gas temperature, active regeneration can generally be initiated over a wider range of vehicle operational conditions. Active regeneration typically takes several minutes to complete, and ends when the DPF has been sufficiently regenerated based on pre-determined limits. DPF regeneration events are typically infrequent and should occur only every few hundred kilometres depending on factors including driving style and driving conditions.

50. Active regenerations impact regulated pollutant and CO_2 emissions. Due to their low frequency, DPF regeneration events usually do not normally occur during certification tests like WLTP and NEDC. To account for this, specific factors, one for each regulated emission and CO_2, are applied in the certification process. These are known as a "**Ki Factor**". These factors are determined by running tests repeatedly over the regulated emissions cycle to determine the frequency and duration of DPF regeneration. Its purpose is to determine the change in cycle emissions influenced by the DPF regeneration frequency and the effect of DPF regeneration on CO_2, NOx and other pollutant emissions and hence is calculated based on the ratio of the number of cycles between regenerations to the number of cycles taken to complete a regeneration and the ratio of emissions with regeneration and without. The principle that these emissions are different in active regeneration applies to all driving situations. Regulated pollutant emissions generally increase during active DPF regenerations, and so the relevant Ki factor is multiplied by the emissions measured during the Type I test for comparison to certification limits. However, the Ki Factors themselves reflect the DPF regeneration behaviour specific to that emissions cycle. See further paragraphs 0 and 80 below.

[23] In light duty engines it is more typical to use late injection of fuel into the cylinder. This fuel then enters the exhaust as unburnt HC, passing through the DOC. The DOC oxidation of the unburnt HC is exothermic, thereby heating the exhaust gas and thus the raising the temperature of exhaust gas entering the DPF (downstream of the DOC).

ii. Diesel Oxidation Catalyst

51. A DOC is a device that converts, through oxidation[24], HC, some PM, and CO into water vapor and CO_2. The DOC is also used during active regeneration of the DPF to oxidise excess HC in the exhaust gas, generating an exothermic reaction to achieve the additional temperatures required for active DPF regeneration. Finally, the DOC oxidises some of the NO to NO_2 – the ratio of these two gases influences the operation of the SCR. The NO_2 produced by the DOC is partially used for passive DPF regeneration.

52. The DOC supports the function of other emissions control components within the engine such as the DPF and the SCR, and will be positioned upstream of these components. On vehicles fitted with an LNT, the function of the DOC may be performed by the LNT and therefore a DOC may not be fitted.

C.3 Other engine components

i. Fuel injection System

53. The main parts of a diesel fuel injection system are the injectors, the high-pressure pump and the common rail. The pump supplies pressurized diesel fuel to the injectors. The injectors spray the appropriate amount of diesel fuel under high pressure into the combustion chamber. The common rail is a fuel manifold with pipes leading to each fuel injector. It stores the pressure generated by the pump and contains an integrated pressure sensor. The common rail is typically in close physical proximity to the combustion chamber. Pressure, number of injections and timing are managed to control emissions, combustion noise and fuel consumption, while ensuring power and combustion stability at a given point of operation. There is variation in the design of fuel pumps, the common rail, fuel pipes and fuel injectors between vehicles.

[24] Oxidation is the chemical reaction of a chemical species with oxygen.

Figure 17: An example of a fuel injector from a diesel engine, with zoomed image of the injector's nozzle

ii. Combustion chamber design and glow plugs

54. A relevant factor for the combustion behaviour is the design of the combustion chamber, where diesel combustion takes place, and the components which relate to it. The number of cylinders in an engine and the physical characteristics of those cylinders varies between engines.

55. One relevant design factor is the volume of the chamber. Similarly, constructive features such as the cylinder design, intake port design, intake valve size, nozzle hole geometry, valve configuration, and geometry of the combustion chamber and fuel injectors affect the combustion process. The cylinders must be fluidically connected to the turbocharger, the intake manifold, the exhaust manifold, the EGR valve, the EGR cooler and close-coupled DOC, LNT, SCR and/or DPF. This is because these components all form a continuous duct network to allow air/exhaust gas to pass into and out of the cylinders.

56. One component adherent to the combustion chamber is the glow plug. Glow plugs are essential components in light-duty diesel vehicles, especially during cold starts at low ambient temperatures. As addressed above, diesel engines rely on heat for fuel to auto-ignite. In cold conditions during start-up, heat in the combustion chamber may be insufficient to initiate combustion. Glow plugs provide a hot point in the combustion chamber to promote ignition of fuel. They are designed and located in relation to the fuel injector to get a small amount of atomized fuel misted on or near them to initiate local combustion. These plugs use electrical energy to reach high temperatures of 850-1300°C at their tips. Glow plugs may remain active during the engine's warm-up phase to improve combustion stability and reduce emissions, particularly at colder ambient temperatures, and to put additional load on the alternator. Both of these effects assist in warming up the engine more rapidly.

iii. Air intake system

57. The main components usually include:

a. **Air filter**: the ambient air first passes through a filter that is designed to prevent particles and condensate from entering the air system and the combustion cylinders. In particular, it is required to prevent damage to the mass airflow sensor (downstream of the air filter), turbocharger compressor and the sliding surfaces of the engine from dust/hard particles. Air filters differ slightly in principle and method of operation, construction, type of filtration media and efficiency of operation, with desirable qualities being good filtration quality accompanied by minimal pressure loss.

b. **Mass Airflow Sensor ("MAF Sensor"):** the MAF Sensor measures the flow of fresh air into the combustion chambers.

c. **Turbocharger**: a turbocharger is a turbine driven system deriving power from an engine's exhaust gases; its purpose is to increase the mass of air/charge ingested into the cylinders. This system involves exhaust gases being directed through a turbine inducing its rotation. The rotating turbine is connected on a common shaft to a compressor which draws fresh air from an inlet. The compressor compresses intake air, increasing both pressure and temperature, and directs the compressed air towards the combustion chamber. When more air is delivered to the combustion chamber, more fuel can be burned enabling increased engine performance and fuel efficiency. Turbocharger designs differ between vehicles. More air improves combustion allowing for increased engine performance: essentially, higher density air means that proportionally increased oxygen mass is introduced to the cylinder and so power output can be increased by adding more fuel in proportion to the additional mass of air induced into the cylinders.

i. There is variation in turbochargers between vehicles. For example, some vehicles may use more than one turbocharger in order to improve transient response and increase boost pressure (i.e. pressure in the intake manifold) over a wider range of operating points.

ii. In addition, some vehicles may use turbochargers equipped with adjustable guide vanes, commonly referred to as variable geometry turbochargers ("**VGT**"), which influence the flow of exhaust gas onto the turbine impeller. By this means, optimal charge pressure and therefore optimised combustion, leading to better control of emissions at the outlet of the combustion chamber, are achieved throughout the engine speed and engine load range. The position of the guide vanes, and therefore boost pressure, are actively controlled by the ECU and are typically adjusted via an electric or vacuum actuator. Alternatively, some turbochargers are fitted with a "**waste-**

gate" to control the boost pressure by allowing some exhaust gases to bypass the turbine.

d. **Charge air cooler**[25]: the charge air cooler, which is only used on turbocharged vehicles and is located downstream of the turbocharger's compressor, cools charged air that has been heated by the turbocharger's compressor by transferring heat from the compressed air to either (i) a liquid coolant or (ii) ambient air, depending on the type of charge air cooler that is in use (air-to-water or air-to-air). The design of the charge air cooler and type of coolant used varies between vehicles.

e. **Intake throttle valve**: a throttle valve in the gas path is positioned such that it can limit (i.e. throttle) the intake fresh air flow depending on its opening degree. This may be installed upstream of the location at which the recirculated exhaust is mixed with the fresh air to induce a sufficient pressure gradient for the recirculated exhaust gas to flow into the intake system.

f. **Intake or inlet manifold**: The intake manifold supplies the charge (air and the exhaust gas recirculated via an EGR system if present) to the cylinders for combustion. The intake manifold distributes charge air to the cylinders.

g. **Intake ports:** The intake port connects the intake manifold to the cylinder. The design of the intake ports affects gas movement in the cylinder which in turn influences the combustion process (e.g. by affecting local AFR distribution and the formation and size of fuel droplets). If there are two intake ports per cylinder each may have a different geometry.

h. **Intake port shutdown flaps or swirl-flaps**: These are control valves attached (if present) to the intake manifold that can be used to control the flow of gases into the combustion chamber to influence the motion of those gases inside the combustion chamber and to enhance fuel-air mixing. This can be used to control combustion.

Figure 18: Examples of swirl flaps[26]

[25] Interchangeably called an intercooler or aftercooler.

[26] Fratita, Rusu, Burciu, "Cold flow simulation for an Internal Combustion Engine with swirl flaps", Figure 1. Open Access proceedings Journal of Physics: Conference series.

i. **Intake valve**: Positioned after the intake manifolds directly at the cylinder head, the intake valves control the flow of the air-exhaust-gas-mix into the cylinder.

j. **Exhaust manifold**: The exhaust manifold collects the exhaust gas after the combustion process and directs them into a single pipe. The exhaust manifold is attached to the cylinder head.

Figure 19: Example exhaust manifolds[27]

iv. Cooling system

58. The temperature of, *inter alia*, the combustion chamber affects the combustion process. Engine temperature is primarily regulated by running liquid coolant around the outside of the combustion chamber. The colder the coolant is, the more it cools down the combustion chamber. If the coolant is too hot, it must be cooled down in turn by passing it through a heat exchanger (the "**Radiator**") where the heat is passed to the ambient air.

59. The coolant water circuit usually consists of two pathways; the short and the long coolant water circuits. Both pathways lead through the engine components that need to be cooled, especially the combustion chambers and, if present and water cooled, the EGR cooler(s). Only the long coolant water pathway runs through the Radiator. A thermostat regulates flow of coolant to the Radiator to control the temperature. Under certain conditions, the cooling system can reach its maximum capacity; under such conditions the engine temperature has to be controlled within safe limits by limiting the engine power.

v. Lubrication system

60. Lubricating oil is pumped for lubricating purposes to the moving parts of the engine like the piston, the crankshaft, the connecting rod, and the camshafts. The oil absorbs the heat of these lubricated parts and passes it on to the engine coolant via a heat exchanger (the oil cooler). The oil is stored in the sump/oil pan which is connected to the intake air circuit of the engine via the crankcase breather. Combustion gases that have leaked from the combustion chamber into the crankcase are fed into the intake system to avoid pressurisation of the crankcase. In addition to engine coolant temperature, engine oil temperatures have an influence on the combustion process.

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[27] Teja, Ayyappa, Katam and Anusha, "Analysis of Exhaust Manifold using Computational Fluid Dynamics, Figure 1. Analysis of Exhaust Manifold using Computational Fluid Dynamics.

D. Engine Control Units

61. The Engine Control Unit ("**ECU**") is a specialised computer that manages the control of a vehicle's engine in "real-time". The ECU runs "firmware" that consists of "software" and a "calibration". The ECU's firmware coordinates the behaviour of the ECS. The ECU's firmware can generally be divided into three components:

    a. **Bootloader**: the code that controls the system start-up and some very basic functions.

    b. **The "software":** an interdependent set of functions that determine what a system can do, for example injecting fuel or opening and closing the EGR valve.

    c. **The "calibration"**: which define the values of each calibratable variable (parameter or "label"), including maps, curves and individual values, that are the inputs to each function in the software.

    In summary, the software defines the mathematical operations of the firmware, while the calibration defines the values used in those mathematical operations.

62. The ECU receives signals (directly or indirectly) from Sensors and feedback from Actuators. Based on this data received from the Sensors and Actuators, the ECU generates and/or adjusts signals sent to the Actuators which influence the vehicle behaviour. By way of example, the ECU receives a signal from the engine speed sensor and from the vehicle's accelerator pedal, translates these (via the software) into numerical values for the engine speed and pedal position, and uses these values in the calculation to determine the quantity of fuel to be injected. In turn, it translates the result of that calculation into signals that are sent to the fuel injectors to yield the injection of the correct quantity of fuel.

63. In addition to values from the calibration, the software functions also use both measured and modelled values. Measured values are based on Sensor and Actuator signals (potentially with minor adaptations). Modelled values are calculated approximations of values that cannot be directly measured, that are based on knowledge of the engine architecture and functionality. The models, and the values used within, need to be calibrated.

64. Within the engine control software, there are tens of thousands of calibratable parameters, which impact all aspects of the powertrain function, including performance, driveability, durability, on-board diagnostics ("**OBD**"), safety, noise emissions and pollutant emissions. Many of these calibrated parameters are calibrated by reference to curves or maps, which are arranged to span the full range of operating points and ambient conditions expected to be experienced by the engine. Calibrations must be tuned to ensure satisfactory vehicle operation under a wide range of conditions, including, *inter alia*, driver behaviour (e.g. how rapidly the

accelerator pedal position is changed), the environment (e.g. ambient temperature, altitude, humidity), and the vehicle hardware (e.g. the number of cylinders) and other physical properties of the vehicle in which the calibration is applied.

65. It is not possible to calibrate responses to every possible permutation of operating point and ambient condition. It is therefore common to have **base maps** that interpolate between a limited number of calibrated operating points (i.e. not every single operating point is calibrated directly or individually). Generally, depending on the capability of the engine control system and the sensors available as inputs, separate base maps can be developed for each discrete level of ambient pressure, ambient temperature or internal engine state variables and stored in the engine control system. Alternatively, change maps or characteristics compared to the standard ambient conditions or internal engine state variables, so-called 'corrections', can be used. It is typical to calibrate software so as to enable more than one correction to be capable of being active, simultaneously, at a given operating condition.

66. It is possible for different vehicle types to use common software, but different calibrations.

67. The components of an ECU's firmware may be modified by an update with the effect that an individual vehicle might have different software and/or calibration versions installed over its life.

68. In addition to the ECU, modern vehicles often employ Additional Control Units ("**ACUs**") which are electronic control units designed to manage specific sub-systems within the vehicle. These ACUs communicate electronically with the ECU and each other.

E. <u>On Board Diagnostics System</u>

69. The ECU also provides OBD functionality, which monitors various vehicle systems and identifies types of deterioration or malfunction of emission related components while the vehicle is being driven on the road. OBD uses both measured and modelled values. For example, the OBD system monitors Sensors and Actuators related to the EGR system. If the EGR valve fails to respond to the ECU's commands, the OBD system shall detect the issue. In some cases, the OBD functions can deliberately and momentarily cause the ECU to alter the behaviour or state of vehicle systems and evaluate the responses to confirm a system is functioning correctly.

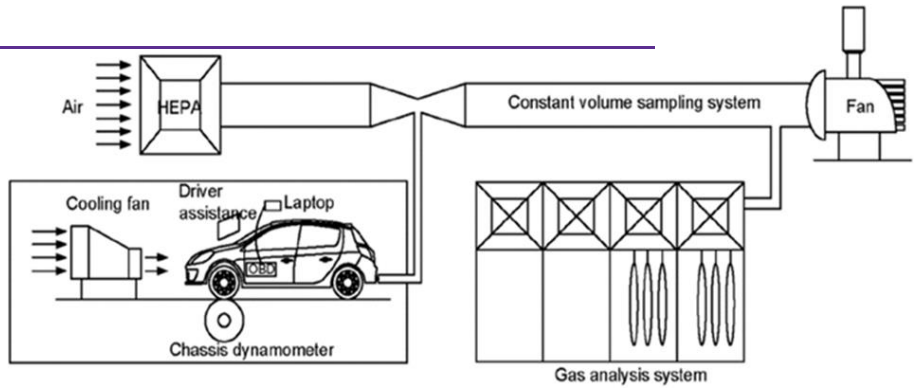
70. The legislative OBD test provisions require testing of components which are simulated to have deteriorated or failed testing is conducted reference to the which are multiples of the Type I test limits.

71. Where the system detects a malfunction component, or the OBD system itself, it signals this to the driver, by the OBD systems (i) detect malfunctions as described above; (ii) store fault codes in the ECU's fault memory (iii) activate the MIL alert to

the driver and (iv) capture data of the relevant engine and system conditions at the time that a code is stored.

72. Fault codes can be retrieved by connecting a diagnostic scan tool to the OBD port.

F. Type-Approval Testing Procedure



a) The New European Driving Cycle ("**NEDC**"); or

b) The Worldwide Harmonised Light Vehicle Test ("**WLT**")

73. The NEDC is a set driving cycle.

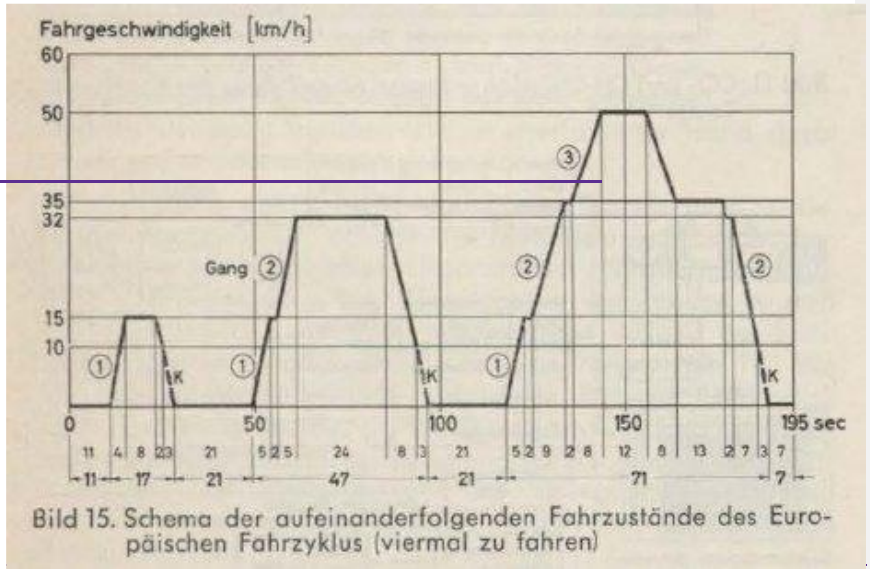


Bild 15. Schema der aufeinanderfolgenden Fahrzustände des Europäischen Fahrzyklus (viermal zu fahren)

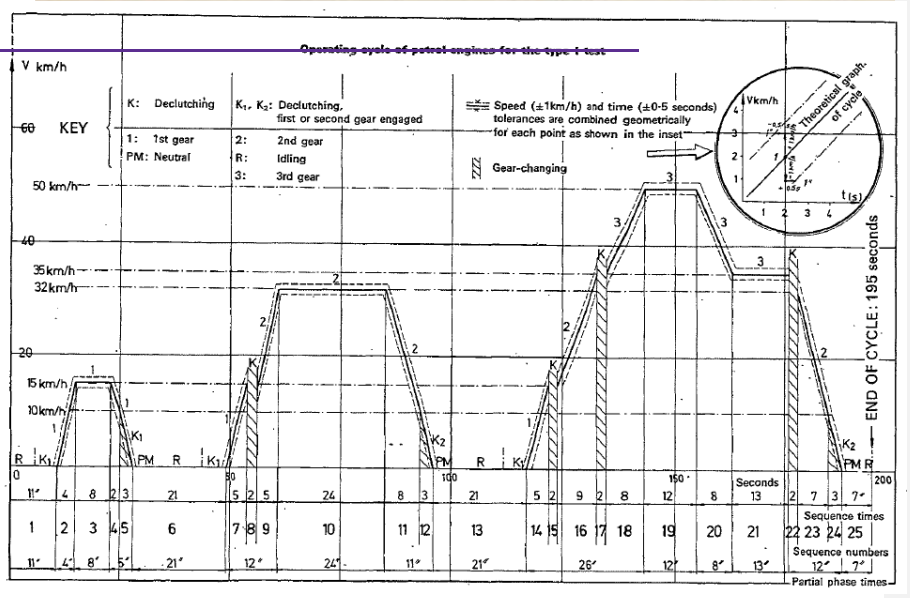
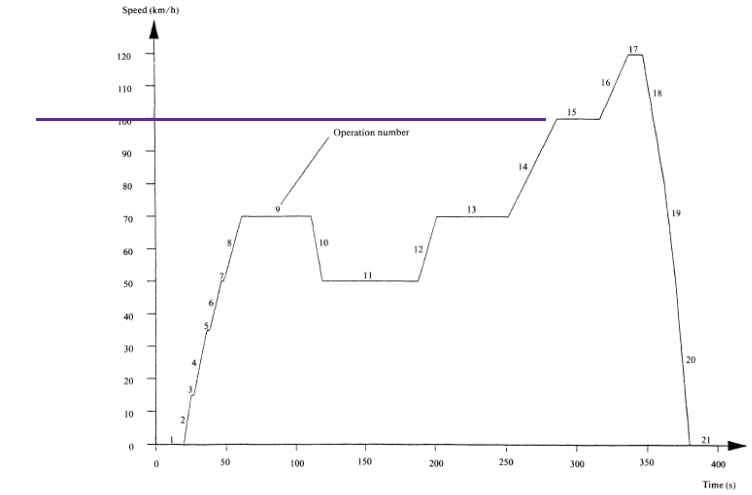
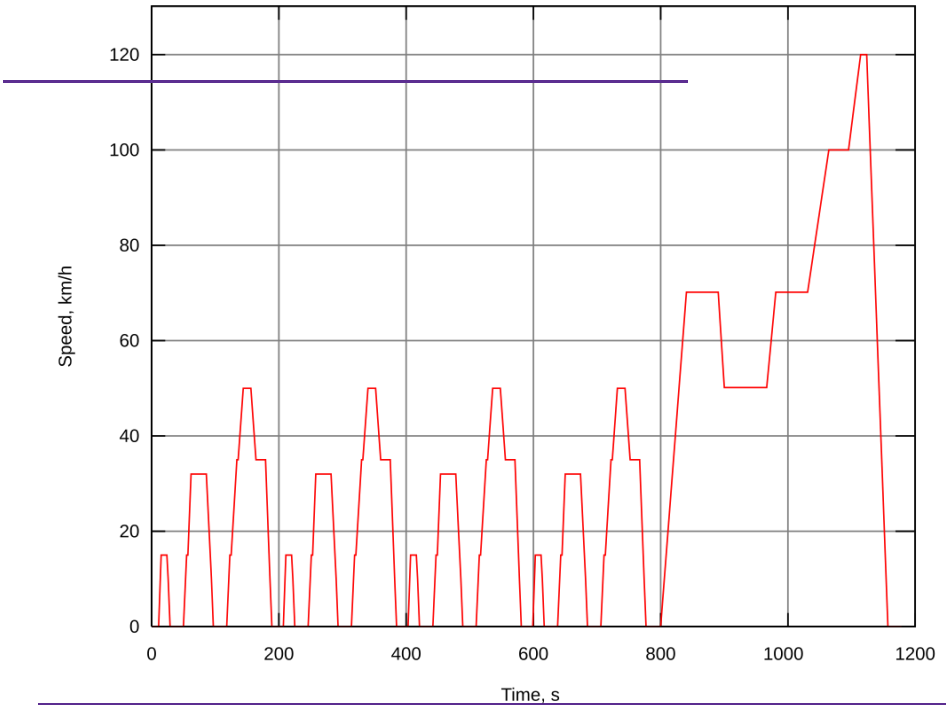


Figure III.1.3

Extra-urban cycle (Part Two) **for the type I test**

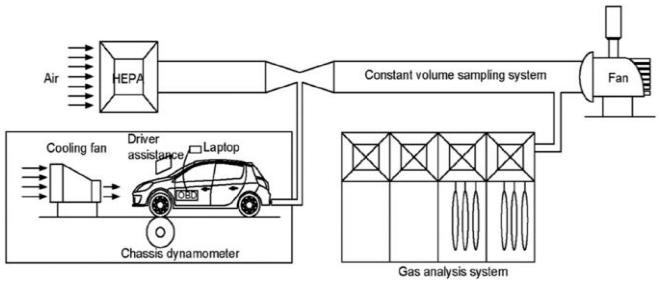




74. Over the course of the emissions measured. For the purposes of the relevant Sample Vehicles, it is the Implementing Regulation and, where referred to therein, UN-ECE

Commented [LH2]: Should the sentence be lengthened?

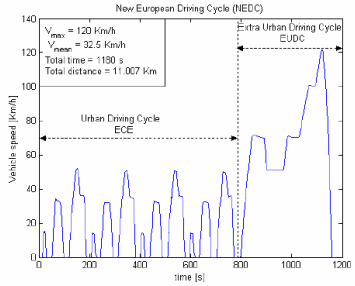
Regulation No. 83 (together, the "**NEDC Regulations**"), as amended over time, that prescribe the particulars of the NEDC test cycle that the relevant Sample Vehicle would have been subjected to for the purposes of Type Approval with respect to Emissions.



75. The operator of the vehicle must drive in accordance with driving cycle. A running time of 19.66 minutes (or 1,180 seconds) consist of two parts:

Part 1: Referred to as the "urban cycle" this consists of 4 elementary urban cycles. They consist of four identical operating cycles with a duration of 195 seconds, each of which must be driven four times in a row with a specified pause in between. For each operating cycle, there are then three separate operating curves with precisely specified time and speed: the first up to 15 km/h, the second up to 32 km/h, the third up to 50 km/h and, with decreasing speed, some seconds at 35 km/h. The distance covered is 4.052 kilometres, the maximum speed is 50 km/h, and the total running time is 13 minutes (4 phases x 195 seconds = 780 seconds).

Part 2: Referred to as the "extra-urban cycle. First, the driver accelerates to 70 km/h and continues at that speed for a specified number of seconds. Then the driver reduces the speed according to the driving line displayed on the monitor to 50 km/h and continues at that speed for a period again specified to the second. The driver then accelerates again to 70 km/h, remains at the line displayed on the monitor for 42 seconds, then further accelerates to 100 km/h and, after a short time, to 120 km/h, and then rapidly reduces speed to 0 km/h. The distance covered is 6.955 kilometres, the maximum speed is 120 km/h and the total running time is 400 seconds.



The NEDC Regulations allow for some tolerances with respect to the drive cycle there are also tolerances relating to test equipment and measurement accuracy.

76. The NEDC Regulations set out conditions and parameters within which the NEDC be driven. These include:

a. **Ambient temperature** – the test cell temperature should be between 293 K and 303 K (20°C and 30°C).

b. **Humidity** – the absolute humidity (H) of the air in the test cell or the intake air of the engine should be such that humidity lies within the range between 5.5 and 12.2

c. **Road load** – the dynamometer on which the test vehicle is driven should be adjusted so that the total inertia of the rotating masses would simulate the inertia and other road load forces acting on the vehicle when driven. ~~on the~~

d. **Fuel quality** – The fuel used during testing must meet specific standards to ensure consistency.

77. Prior to the NEDC test, the test vehicle is preconditioned. Pre-conditioning is a standard conditioning process to prepare the vehicle for the NEDC test and consists of:

a. A preparatory drive – involving the vehicle being driven through the extra-urban cycle of the NEDC three times ~~–~~at most 36 hours, and at least 6 hours, before the NEDC test proper.

b. A soak period – after the preparatory drive and before the NEDC test proper, the vehicle is kept in a room in which the temperature remains relatively constant between 293K (20c) and 303K (30c). This soak- in period should last for at least six hours and continue until the engine oil temperature and coolant, are within +/- 2K of the temperature of the room.

78. Emissions collected during each NEDC test cycle are collected in a sample bag, or for particulates, on a filter. They are averaged over the distance of the test to produce a value in milligrams per km. The procedure provides for an average of three sets of

NEDC results (although only one or two tests may be required if certain criteria are met). It is permitted to exceed the applicable Type I emission limit by up to 10% in one of the three tests provided that the arithmetic mean is below the relevant limit.

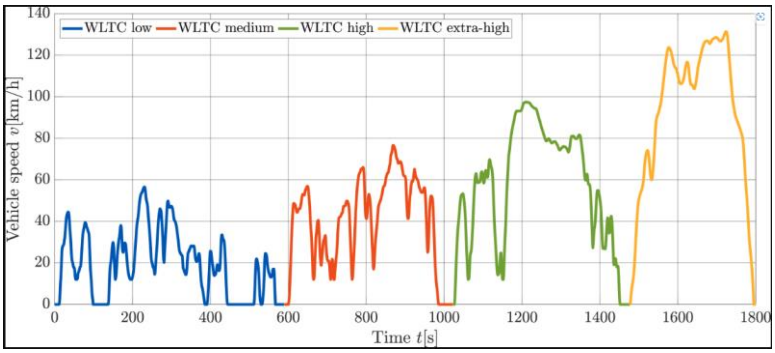
79. The results obtained from the NEDC test are multiplied by a Ki factor for each pollutant (if the vehicle has a periodically regenerating system, such as a DPF) and deterioration factor.

80. It is the averaged milligram per km test results, with the Ki factor for each pollutant and deterioration factor applied, that are required to meet the Type I emission limits specified in Annex to the Emission Regulation, for Euro 5 or Euro 6 vehicles as applicable (e.g. for NOx, 180mg/km or 80mg/km respectively). As it is an averaged result, it is permissible for emissions to exceed the relevant emission limits for parts of the NEDC test.

81. The WLTP is a testing procedure aimed at determining the levels of gaseous, particulate matter, particle number, CO_2 emissions, fuel consumption, electric energy consumption and electric range from light-duty vehicles in a repeatable and reproducible manner designed to[28] The WLTP involves the vehicle being driven according to a cycle defined in Sub-Annex 1 to Annex XXI of Regulation (EU) 2017/1151.

82. Fundamentally, the WLTC is categorized into four speed ranges low 1), medium (2), high (3), and extra high (4), each corresponding to specific driving conditions. The "low" range represents urban traffic, with a maximum speed of 56.5 km/h. The "medium" and "high" ranges simulate inter-urban and express road driving, with maximum speeds of 76.6 km/h and 97.4 km/h, respectively. The "extra high" range reflects motorway driving, where the maximum speed reaches 131.3 km/h. The following figure illustrates the driving profile for the low, medium, high speed ranges of the WLTC.

[28] United Nations Economic Commission for Europe, 'Global Technical Regulation No 15: Worldwide Harmonized Light Vehicles Test Procedure' (13 November 2014) UN Doc ECE/TRANS/180/Add.15, para 1



83. The WLTC is generally considered to be more reflective of real driving conditions compared to the NEDC. The WLTP cycle involves the subject vehicle being driven a more dynamic driving style that is more reflective of real-world driving.

84. As with the NEDC, the WLTP sets out vehicle configuration and environmental conditions at which the cycle is carried out, these include ambient temperature (23°C ± 5 °C humidity.

85. The WLTP involves a preconditioning period before the test proper is carried out. WLTP preconditioning also involves the vehicle being run to a predefined cycle before being put in ambient conditions to "soak" for a minimum of 6 hours and a maximum of 36 hours in an area with a temperature set point of 23 °C.

86. Like the NEDC, average emissions are collected over the period of the defined WLT, and up to three tests are carried out. Testing to determine Ki factors is also carried out for vehicles with periodically regenerating systems, and both Ki factors and deterioration factors are applied to the results obtained on the WLTP cycle. It is the emission results calculated in this way which are required to comply with the emission limits specified in Annex 1 to the Emission Regulation.

87. Additionally, from 1 September 2017, new type approvals could not be granted unless vehicles were road tested against the emissions limits (with conformity factors applied) under the RDE test procedure. Prior to this date, from the coming into force of Regulation 2016/427, no quantitative emissions requirements were set with respect to RDE tests, but manufactures were required to make RDE test results publicly available.

88. The RDE test procedure involves measuring a vehicle's emissions under real-world driving conditions rather than in a controlled laboratory environment (like the NEDC or WLTP). To capture this data directly from the exhaust during testing, a PEMS is mounted on the vehicle, and connected to the exhaust system.

The legislation sets out the 'shares' of urban, rural and motorway driving a valid RDE test must consist:

a. The trip must consist of approximately (i.e. + 10 percent points) 34% urban, 33% rural and 33% motorway driving.

b. Vehicle velocity should normally not exceed 145 km/h, though this may be exceeded by a tolerance of 15 km/h for no more than 3% of the duration of the motorway driving.

c. The average vehicle velocity (including stops) of the urban driving part of the trip should be between 15 and 40 km/h, and stop periods should account for 6 to 30% of the duration of the urban driving part of the trip.

d. The vehicle velocity range during motorway driving should cover between 90 and at least 110 km/h, and the vehicle's velocity must be above 100 km/h for at least 5 minutes.

e. The duration of the trip should be between 90 and 120 minutes, and the start and end point should not differ in their altitude by more than 100 m.

f. Each of the urban, rural and motorway operation parts of the test should be at least 16 km as a minimum distance.

89. The RDE legislation distinguishes between moderate and extended conditions.

90. Over an initial period 31 December 2019 (new type approvals) and:

a. Moderate temperature conditions were: > 3°C and < 30°C.

b. Extended temperature conditions were: > -2°C and < 3°C or > 30°C and < 35°C.

91. Conditions for temperature are specified as follows:

a. Moderate temperature conditions: > 0°C and < 30°C.

b. Extended temperature conditions: > -7°C and < 0°C or > 30°C and < 35°C.

92. Conditions for altitude are specified as follows:

a. Moderate altitude conditions: < 700m above sea level.

b. Extended altitude conditions: > 700m above and < 1300m above sea level.

93. Where emissions are measured during an RDE test conducted in extended conditions, the emissions during the time in which conditions are extended are divided by a factor of 1.6.

94. Vehicles are preconditioned before undertaking an RDE test. Before undergoing a cold-start RDE test, the vehicle must be driven for at least 30 minutes on open roads,

and then parked with its doors and bonnet closed, and kept with its engine off for between 6 and 56 hours before the test. When undertaking a hot-start RDE test, the vehicle is to begin the test with a warm engine and engine coolant temperature and/or engine oil temperature above 70°C.

Appendix A: Summary of the Emissions Control System on each Sample Vehicle

Sample Vehicle Designation	Make	Model	Euro standard	EGR	HP-EGR	LP-EGR	EGR Cooling	SCR	Passive SCR	LNT	Other EATS
MBC1	Mercedes	E220 CDI	5b	Y	Cooled and Uncooled	N	Y	N	N	N	DOC, DPF
MBC6	Mercedes	ML350 BLUETEC 4MATIC	6b	Y	Cooled and Uncooled	N	Y	Y	N	N	DOC, DPF
MBD1	Mercedes	C220 d	6b	Y	Cooled and Uncooled	N	Y	Y	N	N	DOC, DPF
MBD6	Mercedes	GLC 350 d 4MATIC	6b	Y	Cooled and Uncooled	N	Y	Y	N	N	DOC, DPF
FC1	Ford	Focus	5b	Y	Y	N	Y	N	N	N	DOC + DPF
FC5	Ford	Transit	5b	Y	Y	N	Y	N	N	N	DOC + DPF
FC6	Ford	C-Max	6b	Y	Y	N	Y	N	Y	Y	DPF
FD1	Ford	Transit	6b	Y	Y	N	Y	Y	N	N	DOC + DPF
FD3	Ford	Fiesta	5b	Y	Y	N	Y	N	N	N	DOC + DPF
FD5	Ford	Mondeo	6b	Y	Y	N	Y	N	Y	Y	DPF
PCDC3	Citroen	C4 Cactus	6b	Y	Y	N	N	Y	N	N	DOC + DPF
PCDC6	Citroen	C4 Picasso	5b	Y	Y	N	Y	N	N	N	DOC + DPF
PCDD1	Peugeot	2008	6b	Y	Y	N	N	Y	N	N	DOC + DPF
PCDD4	Peugeot	2008	5b	Y	Y	N	Y	N	N	N	DOC + DPF
NC1	Nissan	Qashqai	5b+	Y	Y	Y	N	N	N	N	DOC + DPF
NC2	Nissan	Qashqai	6b	Y	Y	Y	N	N	N	Y	DOC + DPF
ND1	Nissan	Qashqai	6b	Y	Y	Y	N	N	N	Y	DOC + DPF
RC2	Renault	Captur	6b	Y	Y	Y	N	N	N	Y	DOC + DPF
RC3	Renault	Trafic	5	Y	Y	Y	N	N	N	N	DOC + DPF
RD2	Renault	Captur	6b	Y	Y	Y	N	N	N	Y	DOC + DPF

Appendix B: Glossary of terms

Term	Definition
Active regeneration	The periodic regeneration of a DPF where the exhaust gas temperature is purposely raised sufficiently high enough for the trapped PM to be oxidised.
Actuators	Devices that change the physical state of a component, e.g. the position of a valve.
ACU	Additional Control Unit.
AdBlue	Commercial name for DEF ammonia precursor. AdBlue is an aqueous solution of urea.
AFR	Air-to-Fuel Ratio.
Air-fuel mixture	The mixture which is produced as a result of the combination of intake gases and fuel in the combustion chamber.
Ammonia Slip	Unreacted ammonia which may pass through the SCR Catalyst and be emitted via the tailpipe.
Calibration	The part of the Firmware which defines the values of each calibratable variable (parameter or "label"), including maps, curves and individual values, that are used as inputs to each function in the Software.
CO_2	Chemical notation for carbon dioxide.
CO	Chemical notation for carbon monoxide.
Charge Air Cooler	A heat exchanger located downstream of the turbocharger's compressor which cools the air that has been heated by the turbocharger's compressor.
Combustion Products	Products of the combustion process, primarily CO_2, H_2O, NOx, CO, HC and PM (and also SOx).
DEF	Diesel Exhaust Fluid, commercially known as 'AdBlue', a mixture of urea and water.
DeSOx	The periodic removal of SOx from an LNT.
DOC	Diesel Oxidation Catalyst: a catalytic device that converts, through oxidation, HC, some PM, and CO into water vapor and CO_2.
DPF	Diesel Particulate Filter: a device which physically captures diesel particulates preventing their discharge from the tailpipe.
Driving Cycle	A prescribed profile of vehicle speed (and for some cycles, gear shift points) as a function of time, typically used during a regulated emissions test performed in a vehicle emissions test laboratory.
EATS	Exhaust Aftertreatment System, used to refer to one sub-system, e.g. the DPF, or collectively all the sub-systems in a vehicle's exhaust system.
ECS	Emissions Control System.

Term	Definition
ECU	Engine Control Unit: a specialised computer that manages the control of a vehicle's engine.
EGR	Exhaust Gas Recirculation: a process which recirculates exhaust gases back into the combustion chamber of the engine.
EGR Cooler	Heat exchanger which reduces the temperature of the EGR gas passing through it.
EGR Cooler Bypass	EGR pathway in parallel to an EGR Cooler giving the option of running cooled or uncooled EGR to suit different engine operation conditions.
EGR Rate	The amount of recirculated exhaust gas inducted into the combustion chamber relative to the sum of fresh air and recirculated exhaust gas inducted, commonly stated as a percentage.
Firmware	The computer program embedded in the ECU.
H_2O	Chemical notation for water.
HP-EGR	High-Pressure Exhaust Gas Recirculation: an EGR system which directs exhaust gasses from the exhaust manifold, upstream of the turbocharger turbine, into the intake manifold, downstream of the turbocharger compressor.
HC	Hydrocarbons: the generic designation for a range of chemical organic compounds in the engine exhaust containing carbon and hydrogen.
Injection timing	The injection timing describes when, relative to the piston and crankshaft position, fuel is injected into the combustion chamber. If timing is moved earlier it is "advanced", if timing is moved later it is "retarded".
Loading Phase	The phase where NOx emissions are collected within an LNT catalyst when the engine is running on a lean mixture by oxidation of NO to NO_2, catalysed by precious metals on the surface of the support material, and by adsorption of NO_2 onto the storage element.
LNT	Lean NOx Trap: a system which collects NOx emissions within a catalyst as the engine is running on a lean mixture and requires periodic regeneration to remove stored by chemical reduction of NOx.
LP-EGR	Low-Pressure Exhaust Gas Recirculation: a system which has an EGR circuit being placed after the turbocharger turbine and, sometimes, after an after-treatment catalyst.
MAF	Mass Air Flow: the mass flow rate of fresh air entering the combustion chambers.
MAFSP	Mass Air Flow Set Point: which is the desired or target amount of intake air to be delivered to the engine
MIL	Malfunction Indicator Light, a light on the vehicle dashboard that indicates a malfunction to the driver.

Term	Definition
NEDC	New European Driving Cycle: the driving cycle.
N_2	Chemical notation for molecules of nitrogen.
NH_3	Chemical notation for ammonia.
NO	Chemical notation for nitrogen monoxide or "nitrous oxide".
NO_2	Chemical notation for nitrogen dioxide.
NOx	Oxides of nitrogen: the collective term for the sum of NO and NO_2.
O_2	Chemical notation for molecules of oxygen.
OBD	A functionality of the ECU, which monitors various vehicle systems and identifies potential malfunctions.
Passive regeneration	The regeneration of a DPF using NO_2 in the exhaust gas, which occurs naturally whenever the conditions are conducive.
PM	Particulate Matter: a mixture of small particles and liquid droplets generally consisting of soot, organic compounds, inorganic compounds, and metal particles.
PN	"Particulate Number" – as per Reg (EU) 2016/427, Annex IIIA, (1.2.18.).
Purging Phase	The phase where the NOx stored in an LNT Catalyst is converted or purged during a regeneration process which involves a periodic "rich spike" mode to allow the reduction of the stored NOx.
P-SCR	Passive Selective Catalytic Reduction: a system which pairs a LNT with an SCR without DEF injection.
RDE	Real Driving Emissions.
Regulated emissions test	A test consisting of operating a vehicle over a prescribed driving cycle in a vehicle emissions test laboratory, during which the exhaust gas exiting the vehicle's tailpipe is sampled and the masses of each regulated emission are measured.
SCR	Selective Catalytic Reduction, a system that uses a catalyst to reduce NOx in the exhaust gas.
SCR Catalyst	The component of an SCR system, consisting of a substrate upon which a chemical wash-coat is applied which catalyses the reduction reaction.
Sensors	Devices installed in the vehicle to measure certain data which can be transmitted to a control unit, e.g. the ECU.
SO_2	Chemical notation for Sulphur Dioxide.
SOx	Oxides of sulphur, which result from the oxidisation of sulphur that is found in fuel and lubricating oil.
Tailpipe	A vehicle's tailpipe is the visible end portion of the exhaust system where exhaust gases exit the vehicle to atmosphere.

Term	Definition
TDC	Top-Dead Centre: position of the piston reached at the end of an upward stroke and corresponding to the minimum volume of the combustion chamber.
Vehicle emissions test laboratory	A facility where the vehicle is operated on a chassis dynamometer (also called a "rolling road") where regulated emissions tests are performed. Typically, the vehicle is operated over a prescribed driving cycle during which the chassis dynamometer applies loads to the vehicle's wheels to simulate inertia and aerodynamic drag forces and rolling resistance.
WLTC	Worldwide harmonised Light vehicles Test Cycle, the driving cycle used with the WLTP.
WLTP	Worldwide harmonised Light vehicles Test Procedure, the procedures used in which a vehicle is tested over the WLTC.